SOME PROPERTIES OF BEHAVIOURAL BASELINES IN THE RAT AND DISRUPTION BY THE PSYCHOTOMIMETIC DRUGS

Thesis

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P R E F A C E

This dissertation is an original work carried out in the Department of Psychiatry, University of Edinburgh under the supervision of Dr. J.R. Smythies.

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IT IS UNWORTHY OF EXCELLENT MEN TO LOSE HOURS LIKE SLAVES IN THE LABOR OF CALCULATION WHICH COULD SAFELY BE RELEGATED TO ANYONE ELSE IF MACHINES WERE USED.

LEIBNIZ.

CONTENTS

CHAPTER 1

THE OPERANT STANDPOINT

C H A P T E R 1

1.1 At one time the business of psychology was the study of the mind but according to that well-worn cliche, "psychology has lost its mind" and is now the science of behaviour. The current psychological Zeitgeist could be defined as a mellowed behaviourism, softened not by tough opposition but by the acquiescence of a powerful methodology or hardware.

The behaviourist software, or philosophy is still the subject of considerable controversy and the laboratory circus of operant conditioning is good ammunition for the cynic. Whether scorned as a physicalistic behaviourism or tolerated as a methodological behaviourism (Bergmann, 1956), the basic precision of description and terminology can still be mistaken for a pedantic jargon.

The fundamental data of this science are the publicly observable behaviour of organisms. Its aims are an empirical search for the environmental determinants of behaviour, rejecting any recourse to theorizing of a hypothetical nature in favour of the inductive approach.

1.2 A frequent criticism of operant principles is the cry "tautology". For example, on analysis, the statement of the principle of reinforcement boils down to the following, "If an operant is followed by a stimulus that will increase its frequency of occurrence, then its/

/its frequency of occurrence will increase." This often aired circularity is due merely to the fact that a definition has been stated as though it were a proposition and definitions are of necessity tautological. Burgess and Akers (1966) have clarified this anomaly and have compiled a fairly exhaustive list of operant definitions and propositions.

1.3 Bergmann (1956) has written:-

> "Watson had an amazingly naive and almost superstitious distrust of any appeal to the action of the central nervous system."

Watson's attitude was however more of an insight than a fear. The simple fact of the matter is that fifty years ago (and some would say even to-day) our knowledge of neurobiology does not readily lend itself to hypothesising about the behavioural output in terms of a plausible neuronal organisation: i.e. Pavlov who used the word "cortical" in preference to "operant" made a contribution to the science of behaviour and not to neurophysiology. The Skinnerian is not opposed to physiologizing, because he realizes the importance of theory for those who are attempting to explain certain phenomena by using techniques which by definition are inadequate for that purpose. Rather, he has gone to great lengths to show that a science of behaviour can exist without any need to resort to the CNS for/

/for respectability.

Thus the neurophysiologist, with a use for behavioural baselines, has frequently mistaken the behaviourist standpoint for a direct attack upon the validity of his research.

At the moment psychology is probably the most self-critical of all sciences. Perhaps we employ too many professional critics with too few yardsticks.

1.4 Another objection to the behaviourist approach is that it tends to debase or reduce man to a superficial simplicity often representing a dehumanizing influence upon society. A querulous view might be that we are unable to explain those incomprehensible subtleties of mankind which set us apart from the beasts. Skinner (1966) has answered:-

> "To insist that a science of behaviour give a rigorous account of such phenomena in its present state of knowledge is like asking the Gilbert of 1600 to explain a magnetic amplifier or the Faraday of 1840 to explain superconductivity. Early physical scientists enjoyed a natural simplification of their subject matters. Many of the most subtle phenomena were to come into existence only through technical advances in the sciences themselves. Others, though occurring in nature, were not recognised as parts of their fields. The behavioural scientist enjoys no such natural protection. He is faced with/

> /with the full range of the phenomena he studies. He must therefore more explicitly resolve to put first things first, moving on to more difficult things only when the power of his analysis permits".

Koestler (1964) in his recent much criticized appraisal of modern psychology has accused behaviourism of turning from an anthropomorphic view of the rat to a ratomorphic view of man. The question revolves around the conception of behavioural engineering as a successful enterprise. As Skinner (1966) concludes, "The analysis works".

Koestler also points to the false basis of behaviourism in 19th century mechanistic physics and beckons to the probabilistic and nebulous heights of modern quantum mechanics. He fails however to realize that most of our 20th century engineering is based upon 19th century physics and it also works.

1.5 Sidman (1960) has encapsulated the methodology of modern behaviourism and has placed emphasis on the irrational popularity of statistics in the evaluation of experimental results. His main claim is that if a phenomenon cannot be demonstrated within the behaviour of a single organism then it cannot have any psychological meaning or validity.

The present author is of the opinion that most/

/most modern biological research is carried out without recourse to statistical analysis. There is a growing appreciation of the validity of negative results and the need for a descriptive, rather than insightful, statistic.

Psychologists as a breed have usually very little knowledge of how science proceeds beyond the rating scale, and in the past the notion of experimental control has had little meaning or application in psychological research. Operant principles provide the opportunity to carry out experiments where the probability of change is I or 0 and a result is never just significant at the 0.01 level.

It has been demonstrated that some of these results are true for a cross-section of species, man included. This does not imply that the limitations of one species may be present in another.

1.6 This thesis will firstly be concerned with a detailed investigation of the behaviour generated on a particular reinforcement schedule. This schedule, incorporating the selective reinforcement of specific interresponsetimes, has aroused much interest in the past especially pertaining to the function of "collateral behaviour" and "burst responding", two phenomena which are known to develop under such/

/such experimental contingencies.

Secondly, experiments will be described using operant baselines in an analysis of the structure action properties of several hallucinogenic molecules.

C H A P T E R 2

THE DIFFERENTIAL REINFORCEMENT OF A LOW RATE - A REVIEW

CHAPTER 2

2.1 In respondent conditioning time intervals have long been recognised as conditionable stimuli. The Pavlovian school have demonstrated such temporal discrimination in many mammals.

> "Innumerable variations in both the external and internal media of the organism, each of which is reflected in certain states of the cortical nerve cells, may themselves become individual conditioned stimuli."
>
> Pavlov, 1947 P.51

The passage of time as a conditional stimuli in respondent conditioning has been reviewed by Dmitriev and Kochigina (1959).

The first investigations concerning the differential reinforcement of spaced responding in operant conditioning were carried out by D.M. Page in the Columbia laboratory. A discriminative response was established in the white rat where the positive stimulus (S^D) was presented after a period of no responding in the absence of (S^D) i.e. S^Δ. Thus when the S^D appears and the rat responds as by pressing a bar, it is reinforced with a pellet of food after which S^Δ is presented. The S^D is again presented following a period (say 15 seconds) in which no responses during S^Δ have appeared. Any response during S^Δ serves to postpone the presentation of S^D for another 15 seconds./

/seconds. The extinction of S^{Δ} responding, essential to forming a discrimination is accordingly compressed within the early minutes of training and good discriminations (involving very few responses during S^{Δ} and low latencies to the S^{D}) are rapidly established.

2.2 A similar procedure of reinforcement may be used when no specific discriminative stimuli are presented. In such situations a response is reinforced only if it follows a period of non-response. For example, a bar-press is reinforced only if it follows the preceding bar-press by at least 15 secs.

Skinner (1938), used such a technique in a successful attempt to break down high rates of responding that had previously been set up under a FR schedule. His animals quickly reached stability on this schedule (15" spaced) at a suitable low rate of responding, and on the last day of the experiment the original Fixed Ratio was set up as a control, and the rate promptly rose to approximately the value reached before the 15 second delay contingency was inserted. This was the first experiment to show that the time between successive responses in an operant situation (without discriminative stimuli) is a conditionable dimension of behaviour in the rat. Since this time the selective reinforcement of different inter-response times has been shown as an important determinant/

/determinant of behaviour on many reinforcement schedules.

This selective reinforcement of inter-response times would appear to occur in some of the classical Skinnerian schedules. Skinner (1938) observed that the FI schedule produces a considerably lower rate of responding in the rat than does the FR schedule. The lower rate of FI responding was found both from comparison of FI and FR which produce the same number of responses per reinforcement and from comparisons of FI and FR which produce the same number of reinforcements per hour, Skinner (1938) (Calculated by Anger (1956) from Fig. 98 and Table 2). Skinner pointed out that FI favours the reinforcement of long IRT's (Interresponse-Times) more than does FR. Hence the greater reinforcement of long interresponse times by FI may be responsible for the lower response rate. This low rate during FI is a function of a pattern of responding in which the frequency of responding increases through the interval (Ferster and Skinner 1957, Chapter 5). It has been suggested that some form of chain responding or mediating behaviour is involved in this "interval scallop". A chain of responses is a sequence in which each response functions as a discriminative (or eliciting) stimulus changing the probability of occurrence of a further response. Mediating behaviour is a sequence of responses between two events, that serves to transmit the behavioural influence of one event to that of/

/of another.

2.3 Wilson and Keller (1953) investigated the effects of varying the interval parameter of a schedule which generates spaced responding. They found that the rate of responding was directly related to the reciprocal of that interval specified by the schedule to give maximum reinforcement. They also measured the IRT's and found that the median IRT was relatively small compared with the delay interval prevailing. The increases in IRT's with increases in delay interval were regular but slow. In general, their experiment showed that the rate of responding was considerably greater than that which would yield the maximum number of reinforcements and many responses went unreinforced before the response strength was low enough to permit another reinforcement. In other words as the delay intervals increased the number of reinforcements rapidly decreased. This was almost certainly due to the fact that the experiment was not allowed to continue beyond 6 or 7 days on individual delay values.

In the experiment of Wilson and Keller stereotyped behaviour became conditioned during the interval between lever presses. Animals were seen to match delay periods successfully by engaging in bizarre but predictable behaviour patterns. One could say that such behaviour was reinforced by the occurrence of reward when the/

/the bar-press following it was reinforced. This behaviour was termed "collateral behaviour" by Wilson and Keller and is obviously similar to that "superstitious behaviour" described by Skinner (1948). The behaviour was of a different form in each animal and with increase in the length of the delay interval more links were conditioned to the chain of collateral behaviour. The relatively slow increase in the length of the interval between responses as the required value was increased may have merely reflected the fact that the acquisition of these units further removed from the reinforced bar-press becomes increasingly more difficult.

2.4 Sidman (1955) analysed the IRT's on a similar schedule which demanded IRT's greater than 21 seconds for successful responses. A response produced a water reward (using water deprived rats) only if it followed the preceding lever depression by at least 21 seconds. Saline injected control animals produced an IRT distribution with a peak at the shortest recorded IRT value, due to bursts of very short IRT's and usually with a second peak at or just before the minimum reinforced IRT. That is, a large proportion of the responses were spaced less than 3 seconds apart and the remaining responses rose to a peak between 18 and 21 seconds and then displayed a gradual decline.

In 1956 Sidman showed that burst responding/

/responding accounted for 20% of the total IRT's on a similar schedule. He also demonstrated that the probability of a burst response tended to increase as IRT's approached the lower bound of the reinforcement criterion and pointed out that this relationship might be indicative of dependencies even more remote in time.

2.5 Anger (1956) set up a schedule to reinforce only IRT's greater or less than certain fixed values on a VI baseline. This in effect means that if the animal responds after or alternatively before an IRT of certain fixed value and the VI period has offset, then reinforcement occurs. The schedule is a VI with the added contingency that only certain IRT's are reinforced. Ferster and Skinner (1957) called such schedules, "Conjunctive Schedules". Anger's results are in some respects similar to previous studies without the added VI contingency except that he observes no collateral behaviour, not even where very accurate timing is present. This may be due to the effect that the IRT specifications were not gradually introduced as in Wilson and Keller's study. Anger concluded that relative reinforcements per hour not relative reinforcements per interresponse-time, determine response probability. He made use of a now popular statistic known as IRT's/Op. This is an estimate of the conditional probability of a response between x and y seconds after the preceding response,/

/response, given that the subject spends x seconds without responding. It is obtained by dividing the number of IRT's between x and y seconds in duration by the number of IRT's greater than x seconds in duration. It can be shown from the binomial distribution that the IRT's/Op is an unbiased estimate of this probability. The pooled mean of several samples is also unbiased. Short IRT's are found to outnumber long IRT's perhaps because there are more opportunities for short IRT's. It is this difference in number of opportunities which can be corrected for by using the "Interresponse Times/Opportunities" statistic. There can be no doubt that for some purpose this variable is indeed more descriptive in this situation than is the actual numbers of individual IRT's.

Ferster and Skinner (1957) described a schedule which differentially reinforced a low rate, as CRF DRL. Under this schedule a response was reinforced only when it followed the preceding response by a specified time. Experimenters now designate this schedule DRL following Skinner and Morse (1958). This DRL schedule (i.e. Differential Reinforcement of a Low Rate), is identical to the schedules of Wilson and Keller (1953) and Sidman (1955 and 1956 a,b).

2.6 Ferster and Skinner (1957) had incorporated the DRL contingency into many compound schedules. One/

/One of these procedures involved the addition of a DRL LH contingency to a VI schedule. LH stands for limited hold, for example, in a DRL 8 LH 2 schedule a reinforced IRT must be between 8 and 10 seconds in duration. This conjunctive VIDRLLH schedule may be considered as exerting control over the duration of the reinforced IRT on an interval schedule. Ferster and Skinner (1957) added a ratio contingency to this and called it "VI Pacing." Revusky (1963) compared performance on such a schedule under two hunger levels and two VI values, VI 3 min. and VI 8 min. He used a DRL 8 LH 2 contingency and found that both hunger and frequency of reinforcement increased the overall rate of response but the exact effects of these operations were different for different rats. Usually a peak response probability (IRTs/OP) was obtained 8 to 10 seconds after the preceding response indicating adaption to the reinforcement contingency but in some cases this peak was about 2 seconds earlier. One rat exhibited unusually pronounced bursting which seemed to alternate with adaptive temporally spaced responding. Prolonged pauses observable in the cumulative records, particularly following reinforcement were attributed to the fact that IRT's greater than 10 seconds were not reinforced so that as the interval of time since the preceding response became discriminably greater than/

/than 10 seconds the probability of a response became small. This prolonged pause after reinforcement was also obtained by Ferster and Skinner (1957) p. 499 under VI pacing. As would be expected from the overall rates obtained by Revusky both hunger and frequency of reinforcement tended to increase the IRT's/OP; but visual inspection of the differences between pairs of curves for each subject discloses no evidence of an effect of hunger or VI value on the "shape" of the IRT's/OP curve, which is consistent for different rats. This indicates, as Revusky goes on to say, that since the reinforcement contingency did not specify the exact nature of the cues correlated with the passage of time ("clock" in the sense used by Sidman 1956) which the animals could use, perhaps different animals used different clocks and these different clocks were differentially affected by hunger and VI value. Due to the construction of the experimental chamber Revusky was unable to observe his animals working under the DRL LH contingency and so was ignorant of any collateral behaviour involved therein.

2.7 How is an animal able to time an interval successfully? Anger (1963) points out that one need not be aware of the nature of the animal's clock but need only assume that the animal has some source of stimuli that vary with time. Some people would say/

/say that timing behaviour is mediated by overt response chains and others would assume an interval type clock. Blough and Millward (1965) who reviewed the "timing" literature support a stimulus discrimination hypothesis. They conclude that the required chains have only been observed in special instances and even then it is not clear that they are necessary to timing. Unfortunately their review only covers half of the relevant literature.

Let us examine the evidence for "timing" as a function of mediating behaviour or as a stimulus discrimination. In the extensive Russian literature on the discrimination of time in respondent conditioning there is no mention of collateral behaviours. From the "Fixed Interval Scallop" there is evidence of timing but Dews (1962) has shown that this cannot be disrupted by periods of S^{Δ} presentation. Such a finding would tend to discredit any explanation of the scallop in terms of chaining. Kelleher, Fry and Cook (1959) or Anger (1955) did not observe any collateral behaviour during timing. Church and Carnathan (1963) also found no behavioural chaining during the differential reinforcement of latency. Bower (1961) obtained collateral chains in rats by reinforcing runway responses immediately when the running time was relatively long and after a delay when the running time was short./

/short.

Bruner and Revusky (1961) have demonstrated collateral chains in human behaviour. Sidman (1956 a) suggested that the way to study the role of overt mediating responses in timing behaviour is to render the mediating behaviour an explicit reinforced component of the experimental situation. By rendering the mediating behaviour an explicit component of the schedule, it becomes possible to observe and record the behaviour and to manipulate it experimentally.

Dews (1962) has written:-

> "To establish a sequence of responses as being chained or as constituting mediating behaviour, however, it is not sufficient to demonstrate that the sequence is consistent and could so function; it must be explicitly demonstrated that changes in the sequence disrupt the chain or prevent mediation."

One of the most interesting studies of the DRL phenomenon is that of Hodos, Ross and Brady (1962). They tried to determine whether any EEG changes occurred during a multiple schedule of reinforcement consisting of repeated components of avoidance behaviour, a time-out period and a period of DRL. Two monkeys each had bipolar electrodes placed in the amygdaloid complex, globus pallidus, caudate nucleus, medial forebrain bundle, intralaminar nucleus of the thalamus, nucleus reticularis thalami, paraventricular nucleus of the/

/the thalamus and the ventral tegmental nucleus. A general arousal was recorded during the avoidance and DRL components following pretraining. The EEG records showed predominantly fast activity similar to that seen in periods of alertness during the pretraining session. A small but definite increase in frequency was noted during the DRL and avoidance components of the schedule compared with that in the time-out period. The EEG as recorded from the several brain loci did not however reflect the gross differences in behaviour produced by the separate components of the multiple schedule.

During the DRL component of the schedule the EEG records showed artifactual increases in frequency and amplitude due to forms of collateral behaviour. A frequency analysis of the "artifacts" indicated that the movements which had been obscuring the EEG had a consistent and well defined temporal distribution with great regularity during the DRL component. One monkey produced this "artifact" by head nodding and the other by licking the lucite holder of its water bottle. By utilising some simple circuitry it was possible to record these movements on the polygraph. This was one of the first attempts to measure quantitatively the collateral behaviour which had often been observed during timing behaviour.

The first monkey appeared to be making a crude/

/crude estimate of the number of head movements before pressing the lever. As these movements only occurred during the DRL component of the multiple schedule they must have been an essential condition for the execution of reinforced DRL responding, because when they were completely disrupted by the administration of sodium pentobarbital,no particular class interval of time seemed to be predominant in the IRT distribution. With administration of amphetamine however, the distribution of lever-press IRT's is not flattened but rather the peak of the distribution shifts towards the shorter intervals. During an earlier attempt to eliminate movement artifacts from the EEG records Tabasco sauce (particularly unpalatable to monkeys) was liberally applied to the water bottle holder in the hope that the monkey would thereby be encouraged to stop licking. Licking was in fact suppressed but the effect on the DRL was similar to that observed following administration of amphetamine, as the animal began to press the lever at a rate too high to produce reinforcement. In a similar attempt to suppress the licking behaviour a barricade was erected of aluminium strips and wire. This stopped the monkey licking the lucite holder and again caused a dramatic shift in the IRT's towards the shorter intervals and the number of reinforcements the animal received dropped/

/dropped sharply to zero. A local injection of procaine into the neck muscles of the first monkey to facilitate insertion of EMG electrodes was also observed to have similar effects detrimental to DRL performance.

Malott and Cumming (1964) found long post-reinforcement breaks on DRL LH schedules which they related to the observation that following reinforcement "all subjects reliably exhibited a homogeneous response chain consisting of water dipper licking." (p. 236).

More recently Laties etal (1965) carried out an experiment using the rat as subject which verified the conclusions of Hodos, Ross and Brady (1962). Laties etal. discovered tail nibbling collateral behaviour in a rat on DRL 22. They studied the effects of extinction and reconditioning of lever pressing, removal of the lever, suppression of mouth-tail contact by painting the tail with a substance known to be unpleasant to the rat and the pharmacologicl modification of lever pressing by amphetamine. Extinction and reconditioning of the tail nibbling was accomplished with relative ease suggesting that it was operant in nature. Painting the tail with cyclohexamide caused a marked shift of the IRT distribution which led to a large decrease in the frequency of reinforcement and almost wholly abolished mouth-tail contacts. Mouth-tail contacts were/

/were measured by an independent observer pressing simultaneously a switch which was pulsed to a printing counter. Removing the lever from the experimental chamber led to extinction of the tail nibbling behaviour. The duration of the tail nibbling behaviour was generally found to be correlated with the interresponse time and timing was disrupted by procedures which interfered with this tail nibbling. Laties etal. conclude that because of the obvious variations between amount of tail nibbling and efficiency of spaced responding, this rat's tail must have become a source of discriminative stimuli for appropriate spacing of lever presses.

2.8 Our knowledge of the underlying control of burst responding on DRL schedules has not progressed much since the first observations of Sidman (1955, 1956 a,b). Bursting has been obtained by Anger (1955), Conrad etal. (1958), Brady and Conrad (1960) and Ayers and Thompson (1961). In addition Ferster and Skinner (1957) and Revusky (1963) have reported evidence of bursting under VI pacing. Kelleher, Fry and Cook (1959) using food pellets as reinforcers, found very few short IRTs on DRL. The hypothesised that bursting could be a function of adventitious reinforcement induced during the finite operating time of the dipper mechanism. However, Laties and Weiss (1962) have shown that liquid/

/liquid reinforcement does not guarantee very short IRT's. Corman and Shafer (1966) proposed that short IRTs might be reinforced if they occurred during the time taken to ingest a reinforcement. They tested this theory by spatial separation of the lever and the reinforcement mechanism. Burst responding stabilized at around 20% of the total IRT output so it would appear that consummatory stimuli are not involved in the acquisition.

Bursting probably represents a different phenomenon than temporally spaced responding and future experimentation should endeavour to take this into account.

2.9 Schuster and Zimmerman (1961) tested four albino rats on a multiple schedule incorporating two DRL schedules of reinforcement. They used several DRL values in these two components for each animal. Their data suggested that there was induction between the two components of the multiple schedule. It was possible to test the influence of this induction by sometimes removing the higher-valued component from the multiple schedule and replacing it by a blackout condition. After the performance had stabilized the original conditions were reinstated. Transition data in this study indicated that there were two possible factors contributing to the inductive effect between components. Firstly the inductive effect occurred more frequently/

/frequently whenever the reinforcement ratio was close to one. Secondly, there were indications that induction between components was a function of the specific component DRL values, and it seemed possible that an optimal pair of values could be programmed. The induction effect was shown clearly on removal of the higher valued DRL component from DRL 36 DRL 18 and DRL 27 DRL 18. For these two series however the removal of the DRL 36 component resulted in greater change than the removal of the DRL 27 component.

2.10 Holz, Azrin and Ulrich (1963) maintained some pigeons on DRL and found that punishment of all responses reduced the frequency of these responses as a direct function of the punishment intensity. As a consequence of the increased temporal spacing of responses, more reinforcements resulted during punishment. Under higher intensities of punishment, the reinforcement frequency increased to a maximum value and then decreased at the highest intensities. The increased frequency of reinforcement which resulted during punishment did not counteract the suppressive effect of punishment, nor did it lead to a low response rate after punishment was removed. The number as well as the temporal pattern of responses returned to normal. More investigations are required concerning the effects of suppressive/

/suppressive variables upon the acquisition of efficient timing behaviour. Migler and Brady (1964) and Leaf and Muller (1964) have shown that CER procedure does not effect the IRT distributions under DRL control, i.e. Rate is either normal or zero. However, Finocchio (1963) and more recently Blackman (1966) have reported a response facilitation or rate increase during CS presentation.

2.11 Segal-Rechtschaffen (1963) used a second lever such that the first response to occur on this mediating lever, after the DRL interval had timed out was reinforced as was the next response to the DRL lever. Next the food reinforcement on the mediating lever was replaced by a discriminative stimulus i.e. a buzzer signaling time-out of the DRL interval. Under these conditions chaining of behaviour on the two levers was strong and timing on the DRL lever was more accurate than under ordinary DRL conditions. Mediating behaviour weakened slightly as the DRL requirement was lengthened from 16 to 24-60 seconds. Also timing broke down when the buzzer was removed and the mediating behaviour thus disturbed.

2.12 Reynolds (1964b)has verified the effects of deprivation on the pigeon during DRL originally obtained for the monkey by Conrad, Sidman and Herrnstein (1958). Reynolds also discovered that extinction produces/

/produces permanent decreases in rate on the DRL schedule. Both extinction and the level of deprivation changed the overall rate of responding and the form of the function relating the duration of an IRT to its value of IRT's/OP. The value of the IRT's/OP decreased more rapidly for short than longer IRT's, resulting in the emergence of a finer discrimination of IRT duration. Before an animal can become successful on a DRL schedule it must respond at a rate low enough to cause reinforcement. Reynolds says that it is not appropriate to speak of the development of a finer temporal discrimination in the usual sense but rather of its appearance or emergence.

> "Perhaps two of the functions of reinforcement are separable here; the one to maintain responding at an appropriate rate, the other to bring responding under the discriminative control of additional stimuli in whose presence it is reinforced. In the maintained DRL the effects of the first hide the effects of the second. When the effects of the first decrease as in extinction (and with decreases in deprivation), the effects of the second appear."
> Reynolds (1964).

Staddon (1965) found a linear relationship between the reinforcement rate and the reciprocal of the DRL value in the pigeon. He also described some characteristics of DRL responding as a recoverable baseline. The/

/The stable rate was shown to be a function both of the DRL value and of previous experience on other DRL values. On any DRL schedule the stable performance of most pigeons who had been previously exposed to a variety of DRL's showed on IRT distribution with the median equal to the DRL value. However, there was a species specific effect in that pigeons proved unable to match a DRL value longer than 30 seconds.

Ferraro etal. (1965) have made an analysis of extinction and reconditioning on DRL 60. As in previous experiments (Wilson and Keller, 1953; Kelleher, Fry and Cook, 1959) they found that in extinction, timing behaviour was maintained but with a trend towards longer IRTs before responding stopped. It is apparent from this literature that resistance to extinction was greater and responding was maintained for a longer time on shorter DRL values. However the reconditioning reported by Ferraro etal. was not quite so accurate as that described by Reynolds (1964a). This may be due to the fact that rats in Ferraro's experiment were trained for a large number of daily sessions thus providing a very stable and thus more sensitive baseline.

CHAPTER 3

EXPERIMENTS ON A DRL BASELINE

CHAPTER 3

EXPERIMENT 1

This work was carried out in order to ascertain how the proportion of burst responding on a DRL schedule may vary with prolonged training. Previous experiments have established that at stability on DRL, bursting may account for as much as 20% of all IRTs, i.e. Sidman (1956a). Many examples however define stability after less than 50 daily sessions and this is often produced by only a five-day week training regimen. Ferraro etal. (1965) continued training for 140 days on DRL 60 and at this point their data show a proportion of bursting well below 10%. On the basis of previous work (Bradley, 1965) it was felt that bursting might eventually extinguish, as it is never reinforced during DRL.

METHOD

The subjects were three experimentally naive albino rats, E1, E3 and E4 around 90 days old at the beginning of the experiment. An approximate 22hr. water deprivation regimen was maintained throughout and food was available ad libitum in the home cage. The apparatus was a standard one-lever rat chamber (Grason-Stadler E 3125C) fitted with a solenoid operated dipper mechanism and enclosed in a sound-proofed and ventilated chest. All programming and recording equipment was contained in a separate room. The behaviour was monitored on a cumulative recorder. Visual display/

/display counters were used to record the total number of responses, reinforcements and burst responses (i.e. responses occurringafter IRTs less than 5 sec.). After receiving 50 reinforcements on CRF for two days the subjects were exposed to DRL 15 sec. for 7 daily 2hr. sessions. The schedule was then changed to DRL15LH5. After each session a water bottle was available for 15 minutes in the home cage. Training was carried out for seven days per week and after one week the daily session length was altered so that time-out occurred after 250 responses. From this point recording was instigated on Friday, Saturday and Sunday of each week, as counters were only available on these days, but training still took place for all seven days per week. Reinforcement consisted of 0.1 ml. water presented for 1.5 seconds and the DRL interval was timed from the onset of reinforcement.

RESULTS

The results for all three animals are shown in Table 1a, b and c , and graphically displayed in Fig. 1. The total number of IRTs less than 5 seconds are summed across the three consecutive sessions for each week, and expressed as a proportion of the total IRTs (i.e. 750). Bursting falls from 30% to less than 10% throughout the 14 weeks of recording (Fig. 1), that is to say, weeks 2 - 15 of exposure to DRL15LH5 (Table 1). This reduction is common to all three animals and as will be seen in the/

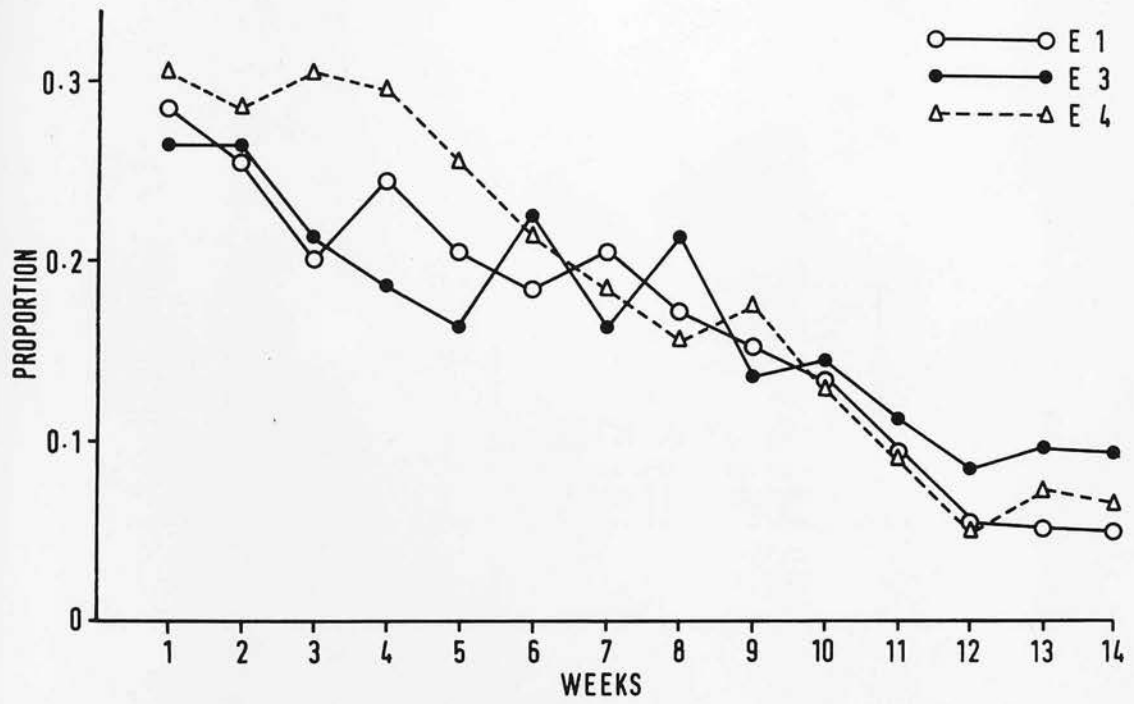


FIGURE [1]

Proportion of IRTs ≤ 5sec. during 14 weeks of training on DRL15LH5 for rats E1, E3 and E4.

	DAY 1	DAY 2	DAY 3	TOTAL	PROPORTION
WEEK 2	54	61	99	214	0.2853
WEEK 3	44	81	67	192	0.2560
WEEK 4	62	50	39	151	0.2013
WEEK 5	71	51	61	183	0.2440
WEEK 6	48	67	39	154	0.2053
WEEK 7	45	44	50	139	0.1853
WEEK 8	57	48	49	154	0.2053
WEEK 9	40	38	53	131	0.1747
WEEK 10	41	25	49	115	0.1533
WEEK 11	46	39	16	101	0.1347
WEEK 12	25	30	17	72	0.0960
WEEK 13	17	9	16	42	0.0560
WEEK 14	13	19	7	39	0.0520
WEEK 15	12	12	14	38	0.0506

TABLE [1a]

Rat E1. Frequency and proportion of $0 \leq$ IRTs < 5 during Weeks 2 to 15 of training on DRL$\bar{1}$5LH5. 250 IRTs recorded per daily session for 3 consecutive days of each Week.

	DAY 1	DAY 2	DAY 3	TOTAL	PROPORTION
WEEK 2	61	44	65	170	0.2666
WEEK 3	58	98	42	198	0.2640
WEEK 4	41	53	68	162	0.2160
WEEK 5	39	43	59	141	0.1880
WEEK 6	43	48	32	123	0.1640
WEEK 7	51	71	47	169	0.2253
WEEK 8	38	48	37	123	0.1640
WEEK 9	30	32	39	101	0.1347
WEEK 10	26	41	36	103	0.1373
WEEK 11	40	28	41	109	0.1453
WEEK 12	25	24	36	85	0.1133
WEEK 13	26	17	20	63	0.0840
WEEK 14	23	25	26	74	0.0987
WEEK 15	21	19	31	71	0.0947

TABLE [1b]

Rat E3. Frequency and proportion of $0 \leq$ IRTs < 5 during Weeks 2 to 15 of training on DRL15LH5. 250 IRTs recorded per daily session for 3 consecutive days of each Week.

	DAY 1	DAY 2	DAY 3	TOTAL	PROPORTION
WEEK 2	79	82	69	230	0.3067
WEEK 3	67	52	94	213	0.2840
WEEK 4	87	62	78	227	0.3027
WEEK 5	78	84	61	223	0.2973
WEEK 6	52	76	63	191	0.2547
WEEK 7	49	57	55	161	0.2147
WEEK 8	35	63	41	139	0.1853
WEEK 9	41	52	24	117	0.1560
WEEK 10	52	42	37	131	0.1747
WEEK 11	36	29	36	101	0.1347
WEEK 12	24	24	23	71	0.0947
WEEK 13	12	20	10	42	0.0560
WEEK 14	16	24	15	55	0.0733
WEEK 15	23	13	13	49	0.0653

TABLE [1c]

Rat E4. Frequency and proportion of $0 \leq$ IRTs < 5 during Weeks 2 to 15 of training on DRL$\bar{1}$5LH5. 250 IRTs recorded per daily session for 3 consecutive days of each Week.

/the next experiment the incidence of small IRTs continues to decrease after even further training.

EXPERIMENT 2

The purpose of this observation was to determine the effects of prolonged training upon the overall distribution of IRTs on the schedule DRL15LH5. For this purpose a printing counter was utilized to print out consecutive IRTs correct to 0.1 seconds. Weiss etal. (1966) have shown that on DRL 20 a point is reached early in training where almost all IRTs satisfy the reinforcement requirements. This experiment compares the performance on the DRL15LH5 schedule between samples at weeks 16 and 23 of continuous daily sessions, in order to examine any change in performance during this time. The experimenter might assume that stability had been reached by week 16.

METHOD

The animals E1, E3 and E4 served as subjects and the experimental situation was exactly as in Experiment 1, except for the added use of a printing counter to record each IRT in sequence. This measurement was taken on the first five days of weeks 16 and 23. There was a one session break between days 3 and 4 of week 23 due to print-out failure, so in that week days 1,2,3,5 and 6 were recorded. Because a Grason-Stadler Counter was not available to end the session after a fixed number of IRTs each daily session was terminated at 90 minutes and the first 300 IRTs were sampled. All IRTs were allocated to/

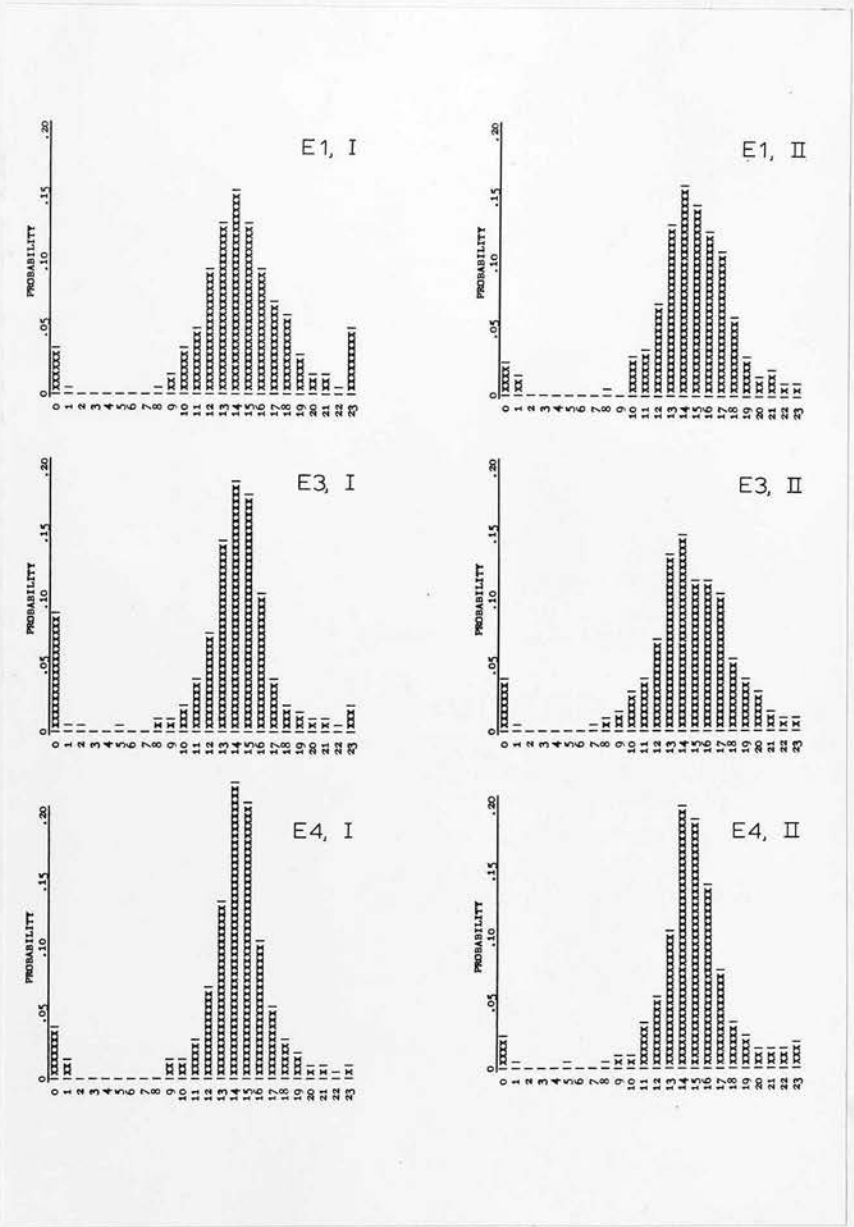


FIGURE [2]

Total IRT Distributions for the first 5 daily sessions in Week 16 (I) and Week 23 (II). Rats E1, E3 and E4.

	E1				E3				E4			
	I		II		I		II		I		II	
T	F	P	F	P	F	P	F	P	F	P	F	P
0	55	3.66	35	2.33	137	9.13	60	4.00	61	4.06	38	2.53
1	10	0.66	24	1.60	9	0.60	4	0.26	26	1.73	9	0.60
2	3	0.20	2	0.13	4	0.26	2	0.13	1	0.06	1	0.06
3	1	0.06			2	0.13	1	0.06	3	0.20	1	0.06
4					1	0.06						
5	1	0.06	1	0.06	4	0.26					4	0.26
6	1	0.06			1	0.06	1	0.06	1	0.06	2	0.13
7	2	0.13	1	0.06	3	0.20	5	0.33	2	0.13	3	0.20
8	9	0.60	4	0.26	12	0.80	15	1.00	1	0.06	5	0.33
9	19	1.26	3	0.20	13	0.86	19	1.26	19	1.26	14	0.93
10	55	3.66	43	2.86	32	2.13	43	2.86	26	1.73	16	1.06
11	73	4.86	49	3.26	60	4.00	62	4.13	44	2.93	55	3.66
12	143	9.53	106	7.06	116	7.73	104	6.93	102	6.80	84	5.60
13	193	12.86	195	13.00	219	14.60	203	13.53	203	13.53	161	10.73
14	231	15.40	239	15.93	285	19.00	225	15.00	338	22.53	299	19.93
15	192	12.80	217	14.46	270	18.00	176	11.73	31	20.93	286	19.06
16	142	9.46	190	12.66	154	10.26	175	11.66	157	10.46	211	14.06
17	105	7.00	162	10.80	58	3.86	161	10.73	81	5.40	113	7.53
18	87	5.80	90	6.00	31	2.06	86	5.73	43	2.86	50	3.33
19	47	3.13	48	3.20	23	1.53	63	4.20	27	1.80	41	2.73
20	25	1.66	26	1.73	14	0.93	42	2.80	16	1.06	23	1.53
21	23	1.53	29	1.93	14	0.93	23	1.53	15	1.00	26	1.73
22	9	0.60	17	1.13	8	0.53	13	0.86	8	0.53	25	1.66
23+	74	4.93	19	1.26	30	2.00	17	1.13	12	0.80	33	2.20

TABLE [2]

Frequency and percentage IRT distributions in 1sec. band widths for the first 5 daily sessions in Week 16 (I) and Week 23 (II). Rats E1, E3 and E4.

/to 1 sec. class intervals up to the end of the 22nd sec., and IRTs greater than or equal to 23 sec. were placed in a dump category signified by 23, i.e. category 'X' contains all the IRTs which satisfy the expression $X \leq IRT < X+1$.

RESULTS

Fig. 2 and Table 2 show that there is a slight change in IRT distribution after a further seven weeks of training. The most striking feature of the distribution is that all six modal IRTs fall in the 14th second just short of the LH or reinforced interval. In the case of all three animals a calculation from Table 2 will show that the prolonged training brought about a small increase in probability of reinforcement. The three distributions for week 23 are slightly flattened and are skewed towards the LH period when compared with week 16. It can also be seen from Fig. 2 that burst responding is almost halved during the 7 weeks extra training.

EXPERIMENT 3

In this manipulation a few simple changes were made in deprivation conditions on DRL15LH5. Previous experiments by Conrad, Sidman and Herrnstein (1958) and Revusky (1963) had shown that increased deprivation raised the overall rate of responding but these effects were different for different rats.

METHOD

Rats E1, E3 and E4 were used after week 23 of training. Each animal was subjected to 48 hrs. deprivation on two occasions and one exposure to 72 hrs. deprivation. Session length was maintained at 90 mins. A possible objection to any evaluation of this experiment is that a change in response distribution, following an increase in deprivation conditions, could be caused merely by the disruption of normal daily training during the deprivation period. To control for this factor, subjects were deprived of training for a comparable time and 30 minutes access to a water bottle was substituted for the daily session. Such a procedure might demonstrate the effect of any incidental interference with the training regimen. Each manipulation was separated by five days of normal training and the order of treatment for each animal was as follows:-

(1) 48 hrs. Deprivation

(2) 48 hrs. Deprivation

(3)/

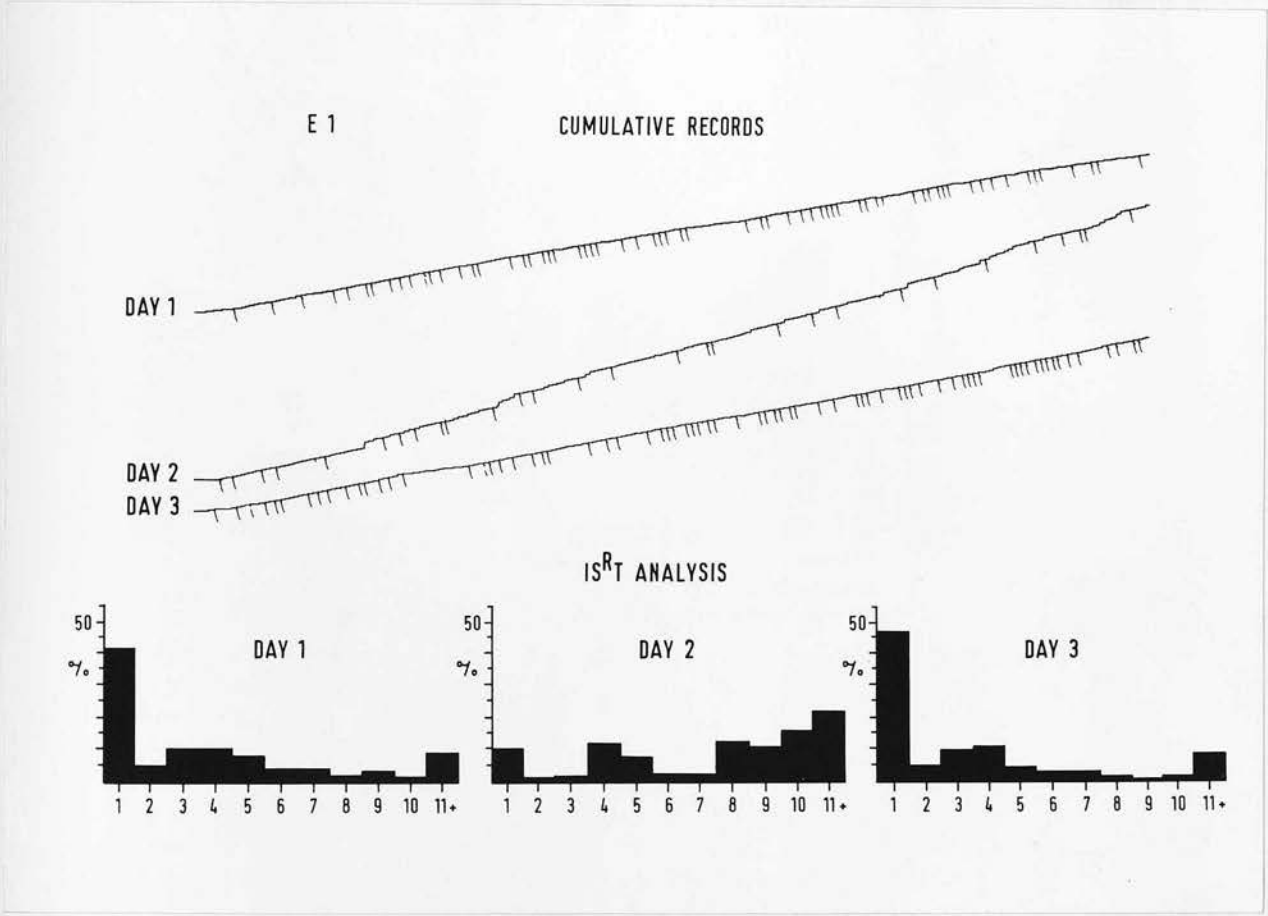


FIGURE [3]

The effects of increased deprivation upon the DRL15LH5 baseline for rat E1.
DAYS 1 and 3 - CONTROL i.e. 22hrs. deprived.
DAY 2 - 72hrs. deprived.

RAT E1

	1	2	3	4	5	6	7	8	9	10	11
CONTROL	.48	.02	.12	.07	.02	.05	.03	.05	.04	.00	.11
48hrs DEPRIVATION	.40	.06	.09	.10	.10	.05	.04	.06	.00	.01	.08
CONTROL	.38	.07	.15	.09	.12	.10	.05	.01	.00	.00	.05
48hrs DEPRIVATION	.42	.03	.06	.17	.09	.05	.06	.02	.00	.03	.07
CONTROL	.42	.05	.10	.10	.07	.04	.04	.03	.04	.03	.10
72hrs DEPRIVATION	.10	.01	.02	.12	.07	.03	.03	.12	.10	.15	.23*
CONTROL	.51	.04	.13	.14	.04	.01	.00	.02	.04	.03	.02
72hrs NO TRAINING	.40	.02	.13	.12	.08	.04	.06	.05	.03	.02	.06

RAT E3

	1	2	3	4	5	6	7	8	9	10	11
CONTROL	.30	.09	.10	.12	.08	.08	.06	.03	.05	.05	.04
48hrs DEPRIVATION	.26	.05	.08	.20	.12	.05	.06	.05	.02	.03	.08
CONTROL	.35	.05	.14	.13	.07	.02	.06	.04	.01	.03	.10
48hrs DEPRIVATION	.33	.07	.15	.10	.04	.03	.04	.04	.04	.02	.14
CONTROL	.24	.11	.14	.18	.10	.06	.05	.02	.03	.01	.06
72hrs DEPRIVATION	.32	.05	.14	.13	.09	.02	.04	.06	.02	.02	.10
CONTROL	.32	.09	.12	.16	.12	.02	.06	.03	.03	.01	.04
72hrs NO TRAINING	.28	.05	.10	.14	.05	.05	.07	.05	.04	.03	.14

RAT E4

	1	2	3	4	5	6	7	8	9	10	11
CONTROL	.45	.10	.10	.11	.03	.03	.02	.05	.03	.05	.02
48hrs DEPRIVATION	.30	.04	.12	.16	.09	.05	.04	.06	.01	.00	.13
CONTROL	.32	.05	.08	.18	.06	.05	.06	.06	.03	.07	.04
48hrs DEPRIVATION	.25	.07	.10	.16	.08	.06	.06	.03	.00	.11	.08
CONTROL	.25	.08	.17	.11	.11	.09	.05	.03	.03	.00	.08
72hrs DEPRIVATION	.13	.10	.10	.18	.15	.07	.04	.07	.05	.02	.09*
CONTROL	.30	.08	.12	.11	.11	.08	.06	.01	.04	.01	.09
72hrs NO TRAINING	.32	.04	.14	.10	.10	.04	.11	.03	.01	.03	.09

TABLE [3]

ISRT Probability Distributions after classification into 10sec. band widths. Rats E1, E3 and E4.

(3) 72 hrs. Deprivation

(4) 72 hrs. No Training. Water given instead of daily session.

A print-out counter was used to measure the time between consecutive reinforcements i.e. IS^RT analysis as described by Farmer and Schoenfeld (1964a). All IS^RTs were allocated to 10 sec. class intervals from 10 sec. to 110 sec. labelled 1 to 10 and IS^RTs greater than or equal to 110 sec. were placed in a dump category signified by 11. Category 'X' contains all the IS^RTs which satisfy the expression $10.X \leq IRT < 10.(X+1)$. For example, IS^RTs in Category 'I' fall between 10 and 20 secs. and thus represent the successive reinforcement of two consecutive lever presses.

RESULTS

Table 3 presents the IS^RT distributions for the four conditions. The session immediately before each deprivation manipulation is also shown as a control. For all three animals 48 hrs. deprivation did not affect the IS^RT distribution in comparison with normal values, so for this treatment it was unnecessary to carry-out a control session with water presentation in lieu of the daily session missed. However, in the case of two out of the three animals (E1 and E4), 72 hrs. deprivation produced a marked breakdown in the IS^RT baseline. Fig. 3 shows cumulative records and the IS^RT distributions illustrating this disruption for rat E1. 72 hrs./

/72 hrs. without training (2 consecutive daily sessions missed) did not produce a similar disruption when deprivation was maintained at the normal value.

E X P E R I M E N T 4

As we have discussed in Chapter 2 collateral behaviour has often been observed on DRL schedules. To see if the temporal discrimination generated by E1, E3 and E4 was in any way mediated by chained responding, closed-circuit television was used to monitor the behaviour within the experimental chamber. Rats E1 and E3 showed no consistent or stereotyped activity at any time but E4 spent the entire post-reinforcement IRT licking in the region of the dipper aperture. This licking behaviour followed every reinforcement taken and was continued uninterrupted until the next lever-press. Licking almost never occurred after a non-reinforced response. An attempt was made to disrupt this post-S^R licking behaviour, to estimate its importance in the generation of the normal DRLLH distribution.

METHOD

As in Experiment 2 a print-out counter was used to record consecutive IRTs. A television camera was installed in the experimental room and one side of the enclosing chamber was removed to permit observation. To suppress the licking behaviour of E4 a paste containing quinine was applied to the dipper shield and dried off. This application and drying procedure was repeated three times to ensure an effective coating. The experimental design was to alternate each of five quinine treatments/

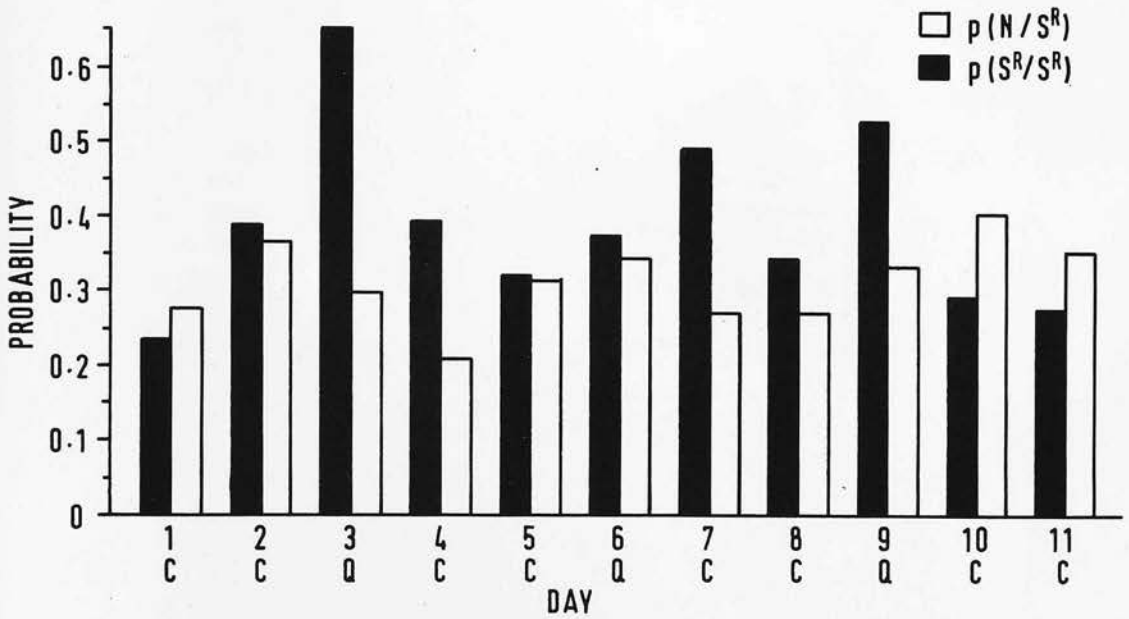


FIGURE [4]

Conditional Probability of a reinforced response following a non-reinforced response, p(N|SR) and following a reinforced response, p(SR|SR) for all Control (C) and Quinine (Q) sessions in rat E4.

		NSR/N	p(N|SR)	SRSR/SR	p(SR|SR)
CONTROL	1	61/220	0.277	19/80	0.237
CONTROL	2	69/187	0.368	44/113	0.389
QUININE	3	48/161	0.298	91/139	0.654
CONTROL	4	48/221	0.217	31/79	0.392
CONTROL	5	65/204	0.318	31/96	0.322
QUININE	6	67/193	0.347	40/107	0.373
CONTROL	7	53/197	0.269	50/103	0.485
CONTROL	8	58/211	0.274	31/89	0.348
QUININE	9	59/175	0.337	66/125	0.528
CONTROL	10	78/190	0.410	32/110	0.290
CONTROL	11	71/202	0.351	27/98	0.275

TABLE [4]

Frequencies and Conditional Probabilities for reinforced and non-reinforced responses during Control and Quinine treatment sessions. 300 IRTs per daily session. Rat E4.

/treatments with two days of normal session. This would involve 5 quinine sessions plus 6 sets of 2 sessions as control, i.e. a total of 17 days. However due to print out failure the first two quinine sessions were discarded and thus eleven days including three quinine treatments are described. Each session was terminated after 90 minutes and the first 300 IRTs were sampled and classified into 1 sec. bands as in Experiment 2.

RESULTS

Quinine treatment was entirely effective in the suppression of post-S^R licking. On first contact with the quinine paste E4 produced an IRT of 309 secs. but after this, no abnormal effect was observed, and contact with the dipper shield was terminated immediately on release of the dipper arm. The conditional probability of reinforcement after reinforcement, and of reinforcement after a non-reinforced response, was calculated for all eleven days. (Figure 4, raw data in Table 4). There is a slight tendency for an increase in $p(S^R|S^R)$ during quinine treatment. This seems unusual at first sight as one would expect any disruption of collateral behaviour to decrease the probability of reinforcement. Figure 5 (raw data in Table 5) breaks down these probabilities into three distributions for the sum of all IRTs during both control and quinine treatment sessions. Distributions are/

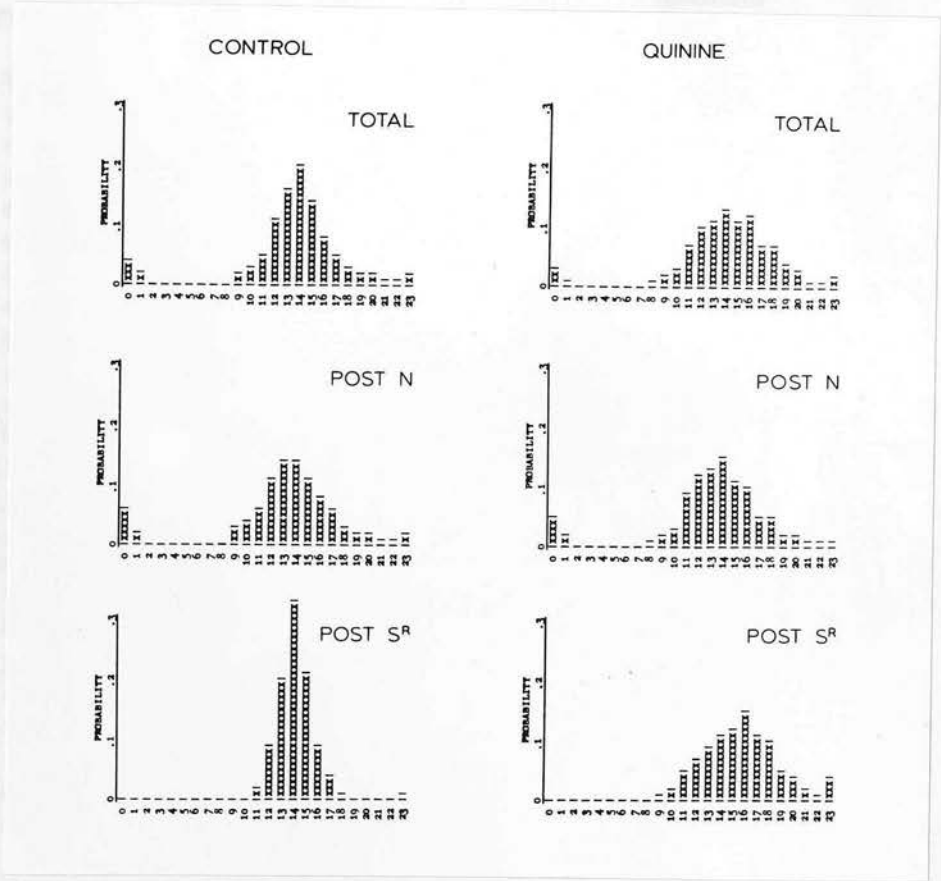


FIGURE [5]

Total, Post-N and Post-S^R IRT Distributions for the sum of all IRTs in both Control and Quinine treatment sessions for rat E4. Control N = 2,400 and Quinine N = 900.

	CONTROL						QUININE					
	POST N		POST SR		TOTAL		POST N		POST SR		TOTAL	
T	F	P	F	P	F	P	F	P	F	P	F	P
0	105	6.43	1	0.13	106	4.42	26	4.91			26	2.88
1	38	2.33	3	0.39	41	1.71	10	1.89			10	1.11
2	3	0.18			3	0.13	2	0.37			2	0.22
3	5	0.31			5	0.21	1	0.18			1	0.11
4	3	0.18			3	0.13	1	0.18			1	0.11
5	4	0.25			4	0.16	2	0.37			2	0.22
6	3	0.18			3	0.13	2	0.37	1	0.26	2	0.22
7	3	0.18			3	0.13	2	0.37	1	0.26	3	0.33
8	2	0.12			2	0.08	4	0.75	1	0.26	5	0.55
9	43	2.63	2	0.26	45	1.88	13	2.45	2	0.53	15	1.67
10	66	4.04			66	2.75	15	2.83	8	2.15	23	2.56
11	103	6.31	15	1.95	118	4.92	47	8.88	19	5.12	66	7.33
12	183	11.21	69	8.98	252	10.50	62	11.72	26	7.00	88	9.78
13	222	13.60	150	19.53	372	15.50	70	13.23	33	8.89	103	11.44
14	233	14.28	254	33.07	487	20.29	79	14.93	42	11.32	121	13.44
15	179	10.96	159	20.70	338	14.08	56	10.58	46	12.39	102	11.33
16	135	8.27	68	8.85	203	8.46	55	10.39	55	14.82	110	12.22
17	101	6.19	28	3.64	129	5.36	26	4.91	40	10.78	66	7.33
18	54	3.30	7	0.91	61	2.54	24	4.53	36	9.70	60	6.67
19	34	2.08	3	0.39	37	1.54	13	2.45	20	5.39	33	3.67
20	36	2.20	2	0.26	38	1.58	8	1.51	16	4.31	24	2.67
21	26	1.59			26	1.08	4	0.75	8	2.15	12	1.33
22	13	0.80	2	0.26	15	0.62	3	0.56	3	0.80	6	0.67
23+	38	2.33	5	0.65	43	1.79	5	0.94	14	3.77	19	2.11

TABLE [5]

Post-N, Post-SR and Total Frequency and Percentage IRT Distributions in 1sec. band widths for the sum of all IRTs in both the Control and Quinine sessions. Rat E4.

/are presented for total IRT output, post-non-reinforced response (post-N) and post-reinforced response (post-S^R). The control data show that the post-S^R distribution represents a more precise temporal discrimination than the post-N distribution and reinforcement is more probable after reinforcement than after a non-reinforced response. Though the post-S^R distribution is the more accurate and contains a greater proportion of reinforced IRTs, it too has the modal IRT in the 14th second, just short of the LH period. The distributions for the sum of all three quinine treatments reveal that the post-S^R distribution is dramatically flattened while the post-N distribution is similar to the control data. Thus the blockade of post-S^R licking has interfered with the temporal discrimination after reinforcement but the peak of this distribution is shifted towards the 16th second. The post-S^R and post-N distributions are identical except for the difference in modal values. As licking behaviour was suppressed after reinforcement it might be hypothesized that E4 was now using post-S^R, the same strategy as he had been using post-N. As S^R occupies 1.5 sec. one would expect the new post-S^R distribution to have a comparable displacement to the right. This is exactly what appears in the data.

EXPERIMENT 5

In the previous experiment evidence was presented in confirmation of the finding by Farmer and Schoenfeld (1964b) that a more precise temporal discrimination may be instigated by a reinforcement than by a non-reinforced response. In order to further examine this serial effect, some more detailed 1st order distributions were calculated on a DRL15LH5 baseline.

METHOD

The subject was a male albino rat F10, and the behaviour was sampled for 25 consecutive daily sessions, after 132, 90 minute training sessions on DRL15LH5. The 25 sessions fell between days 133 and 157. Training conditions and apparatus were exactly as in the previous experiments. In order to maximise the size of the IRT sample from the 25 consecutive daily sessions, a daily session was only terminated when a IRT greater than 120 sec. was recorded. These IRTs correct to 0.1 sec. were transcribed onto punched tape and analysed by E.E.L.M. KDF 9 Computer (Edinburgh Regional Computing Service). All programs were written by the present author in the computer language "ATLAS AUTOCODE".

(A) The first program "THREE" carries out the following calculations and print-out:-

(1)/

/(1) Classification of IRTs up to 25 sec. into 5 sec. band widths coded from 1 to 5. All IRTs $\geq$ 25 sec. were coded as 6.

(2) Print-out 0 order. - Frequencies, percentages and IRTs per OP.

(3) Print-out 1st order. - Frequencies, conditional probabilities (cp's) and IRTs per OP in matrix form. First member of a pair given by row number. Second member of a pair given by column number.

(4) Print-out 2nd order. - Frequencies and conditional probabilities in matrix form. 1st member of a triad given at top of matrix, 2nd member given by row number and 3rd member by column number. Conditional probability refers to the probability of the 3rd member of a triad, given the identity of the first two members.

Program "THREE" is contained in Computer Appendix 1. Another program "PROBE INFORMATIC 6 BY 4TH" is enclosed in the same appendix. This program carries out a similar classification and prints out the frequency and cp for the last member of all combinations present up to 3rd order, preceded by an identification of the combination. Non-existent combinations are not listed and 'Averaged Uncertainties' are also calculated./

/calculated.

(B) A second program "MESCALINE" was utilized in this experiment and carried out the following function:-

(1) Classification of IRTs into 1 sec. band widths coded from 0 to 22. All IRTs $\geq$ 23 sec. were coded as 23.

(2) Print-out 0 order. - Frequencies, percentages and IRTs per OP.

(3) Print-out 1st order. - Frequencies, IRTs per OP, and cp's for 2nd member and 1st member of any pair, in matrix form. First member of a pair given by row number. Second member of a pair given by column number.

Program "MESCALINE" is contained in Computer Appendix 2. Program "HISTOSTAT RED" in Computer Appendix 3 was used to compute 1st order cp's in 1 sec. band widths. A tape output from "HISTOSTAT RED" produces 1st order cp histograms, for all binary combinations of successive IRTs where the first member of a pair occupies more than 4% of the total number of IRTs recorded. Columns within the LH period were printed in red. All the IRT histograms included in this thesis were printed out by a Friden Flexowriter controlled by tape output from variations on program "HISTOSTAT RED".

RESULTS /

F10 TWENTY-FIVE CONSECUTIVE DAILY SESSIONS AT BEHAVIOURAL STABILITY.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23+
1	22	11	1	1	0	0	0	0	0	5	2	7	20	40	55	70	31	22	6	4	3	2	2	5
2	7	2	0	1	0	0	0	1	0	2	4	9	15	29	54	32	22	19	9	5	3	2	2	7
3	13	8	0	0	0	0	1	0	0	3	3	8	20	43	72	59	38	10	7	7	1	1	0	8
4	10	1	0	1	0	1	0	2	0	4	9	16	28	35	56	59	31	19	9	7	8	8	5	7
5	6	2	1	0	0	0	0	0	1	2	7	13	20	36	75	58	30	19	9	7	4	2	3	18
6	5	1	0	0	0	0	1	0	1	6	5	11	18	44	49	55	30	14	10	5	5	4	1	15
7	11	1	1	0	0	0	0	0	1	1	3	3	19	18	37	54	25	22	10	8	5	5	2	13
8	4	2	1	0	0	2	0	1	6	4	6	16	11	21	48	46	19	4	8	2	2	3	1	5
9	14	0	1	0	0	1	0	0	0	1	5	7	18	24	54	50	25	23	12	8	9	3	2	12
10	8	2	1	0	0	0	0	0	0	3	9	19	18	39	68	55	42	21	14	9	6	6	3	22
11	8	1	0	0	0	0	0	0	0	1	8	17	25	47	35	28	22	10	9	6	3	1	0	12
12	13	1	0	0	0	0	0	0	0	1	13	10	27	37	56	64	12	6	7	3	2	0	2	2
13	9	0	0	0	1	0	0	0	0	0	4	5	12	14	35	26	23	10	7	7	6	3	3	11
14	20	2	1	0	0	0	0	0	2	3	4	19	30	42	58	48	37	9	12	6	4	2	2	9
15	5	3	0	0	0	0	0	2	1	1	5	16	35	39	65	44	36	14	19	16	4	4	2	22
16	9	5	2	1	0	1	0	2	5	5	10	20	27	49	51	39	35	24	12	6	6	6	3	26
17	9	7	0	0	0	0	0	0	2	4	7	11	17	31	71	55	22	14	14	6	9	2	8	17
18	2	8	2	0	0	2	1	2	1	5	16	13	37	48	50	47	15	19	4	4	1	2	2	13
19	1	3	0	0	0	0	0	1	2	1	7	10	23	39	39	40	22	15	15	8	6	11	3	29
20	1	3	1	0	0	0	1	0	0	1	6	6	11	29	42	29	25	28	16	8	10	5	7	24
21	8	3	0	1	1	0	1	4	4	11	22	29	44	52	70	40	28	15	11	5	6	8	2	10
22	2	0	0	1	0	0	0	1	2	2	3	7	14	29	42	33	16	18	13	10	3	3	3	10
23	4	2	0	0	0	0	1	0	3	6	31	14	31	71	72	55	30	13	7	7	3	4	2	2
24	6	0	0	1	0	1	0	1	2	4	6	22	33	57	71	55	19	18	11	8	4	3	3	7
25	2	1	1	0	1	1	0	0	0	5	5	11	23	42	52	45	18	30	19	8	8	4	9	23

TABLE [6a]

Frequency IRT Distributions in 1sec. band widths. Rat F10 sessions 133 to 157 on DRL15LH5. IRT > 120 sec. terminates a daily session.

F10 TWENTY-FIVE CONSECUTIVE DAILY SESSIONS AT BEHAVIOURAL STABILITY.
IRT PROBABILITIES

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23+
1	.07	.04	.00	.00	.00	.00	.00	.00	.00	.02	.01	.02	.06	.13	.18	.23	.10	.07	.02	.01	.01	.01	.01	.02
2	.03	.01	.00	.00	.00	.00	.00	.00	.00	.01	.02	.04	.07	.13	.24	.14	.10	.08	.04	.02	.01	.01	.01	.03
3	.04	.03	.00	.00	.00	.00	.00	.00	.00	.01	.01	.03	.07	.14	.24	.20	.13	.03	.02	.02	.00	.00	.00	.03
4	.03	.00	.00	.00	.00	.00	.00	.00	.00	.01	.03	.05	.09	.11	.18	.19	.10	.06	.03	.02	.03	.03	.02	.02
5	.02	.01	.00	.00	.00	.00	.00	.00	.00	.01	.02	.04	.06	.12	.24	.19	.10	.06	.03	.02	.01	.01	.01	.06
6	.02	.00	.00	.00	.00	.00	.00	.00	.00	.02	.02	.04	.06	.16	.17	.20	.11	.05	.04	.02	.02	.01	.00	.05
7	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.01	.08	.08	.15	.23	.10	.09	.04	.03	.02	.02	.01	.05
8	.02	.01	.00	.00	.00	.01	.00	.00	.03	.02	.03	.08	.05	.10	.23	.22	.09	.02	.04	.01	.01	.01	.00	.02
9	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02	.03	.07	.09	.20	.19	.09	.09	.04	.03	.03	.01	.01	.04
10	.02	.01	.00	.00	.00	.00	.00	.00	.00	.00	.03	.06	.05	.11	.20	.16	.12	.06	.04	.03	.02	.02	.01	.06
11	.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.03	.07	.11	.20	.15	.12	.09	.04	.04	.03	.01	.00	.00	.05
12	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.05	.04	.11	.14	.22	.25	.05	.02	.03	.01	.01	.00	.01	.01
13	.05	.00	.00	.00	.01	.00	.00	.00	.00	.00	.02	.03	.07	.08	.20	.15	.13	.06	.04	.04	.03	.02	.02	.06
14	.06	.01	.00	.00	.00	.00	.00	.00	.01	.01	.01	.06	.10	.14	.19	.15	.12	.03	.04	.02	.01	.01	.01	.03
15	.02	.01	.00	.00	.00	.00	.00	.01	.00	.00	.02	.05	.11	.12	.20	.13	.11	.04	.06	.05	.01	.01	.01	.07
16	.03	.01	.01	.00	.00	.00	.00	.01	.01	.01	.03	.06	.08	.14	.15	.11	.10	.07	.03	.02	.02	.02	.01	.08
17	.03	.02	.00	.00	.00	.00	.00	.00	.01	.01	.02	.04	.06	.10	.23	.18	.07	.05	.05	.02	.03	.01	.03	.06
18	.01	.03	.01	.00	.00	.01	.00	.01	.00	.02	.05	.04	.13	.16	.17	.16	.05	.06	.01	.01	.00	.01	.01	.04
19	.00	.01	.00	.00	.00	.00	.00	.00	.01	.00	.03	.04	.08	.14	.14	.15	.08	.05	.05	.03	.02	.04	.01	.11
20	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.02	.02	.04	.11	.17	.11	.10	.11	.06	.03	.04	.02	.03	.09
21	.02	.01	.00	.00	.00	.00	.00	.01	.01	.03	.06	.08	.12	.14	.19	.11	.07	.04	.03	.01	.02	.02	.01	.03
22	.01	.00	.00	.00	.00	.00	.00	.00	.01	.01	.01	.03	.07	.14	.20	.16	.08	.08	.06	.05	.01	.01	.01	.05
23	.01	.01	.00	.00	.00	.00	.00	.00	.01	.02	.09	.04	.09	.20	.20	.15	.08	.04	.02	.02	.01	.01	.01	.01
24	.02	.00	.00	.00	.00	.00	.00	.00	.01	.01	.02	.07	.10	.17	.21	.17	.06	.05	.03	.02	.01	.01	.01	.02
25	.01	.00	.00	.00	.00	.00	.00	.00	.00	.02	.02	.04	.07	.14	.17	.15	.06	.10	.06	.03	.03	.01	.03	.07

TABLE [6b]

Probability IRT Distributions in 1sec. band widths. Rat F10 sessions 133 to 157 on DRL15LH5. IRT > 120 sec. terminates a daily session.

F10 TWENTY-FIVE CONSECUTIVE DAILY SESSIONS AT BEHAVIOURAL STABILITY.
IRTs per OP

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23+
1	.07	.04	.00	.00	.00	.00	.00	.00	.00	.02	.01	.03	.08	.17	.28	.48	.41	.50	.27	.25	.25	.22	.29	1.00
2	.03	.01	.00	.00	.00	.00	.00	.00	.00	.01	.02	.04	.08	.16	.35	.32	.32	.40	.32	.26	.21	.18	.22	1.00
3	.04	.03	.00	.00	.00	.00	.00	.00	.00	.01	.01	.03	.08	.17	.35	.45	.53	.29	.29	.41	.10	.11	.00	1.00
4	.03	.00	.00	.00	.00	.00	.00	.01	.00	.01	.03	.06	.10	.14	.27	.39	.33	.30	.20	.20	.29	.40	.42	1.00
5	.02	.01	.00	.00	.00	.00	.00	.00	.00	.01	.02	.04	.07	.14	.33	.39	.33	.31	.21	.21	.15	.09	.14	1.00
6	.02	.00	.00	.00	.00	.00	.00	.00	.00	.02	.02	.04	.07	.19	.26	.40	.36	.26	.25	.17	.20	.20	.06	1.00
7	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.01	.09	.09	.20	.38	.28	.34	.23	.24	.20	.25	.13	1.00
8	.02	.01	.00	.00	.00	.01	.00	.00	.03	.02	.03	.09	.06	.13	.35	.50	.43	.16	.38	.15	.18	.33	.17	1.00
9	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02	.03	.08	.11	.27	.35	.27	.33	.26	.24	.35	.18	.14	1.00
10	.02	.01	.00	.00	.00	.00	.00	.00	.00	.01	.03	.06	.06	.14	.28	.31	.34	.26	.23	.20	.16	.19	.12	1.00
11	.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.04	.08	.13	.27	.28	.31	.35	.24	.29	.27	.19	.08	.00	1.00
12	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.05	.04	.12	.19	.36	.65	.35	.27	.44	.33	.33	.00	.50	1.00
13	.05	.00	.00	.00	.01	.00	.00	.00	.00	.00	.02	.03	.08	.10	.27	.27	.33	.21	.19	.23	.26	.18	.21	1.00
14	.06	.01	.00	.00	.00	.00	.00	.00	.01	.01	.01	.07	.12	.18	.31	.37	.46	.20	.34	.26	.24	.15	.18	1.00
15	.02	.01	.00	.00	.00	.00	.00	.01	.00	.00	.02	.05	.12	.15	.29	.27	.31	.17	.28	.33	.12	.14	.08	1.00
16	.03	.01	.01	.00	.00	.00	.00	.01	.02	.02	.03	.07	.10	.19	.25	.25	.30	.29	.20	.13	.15	.17	.10	1.00
17	.03	.02	.00	.00	.00	.00	.00	.00	.01	.01	.02	.04	.06	.12	.33	.37	.24	.20	.25	.14	.25	.07	.32	1.00
18	.01	.03	.01	.00	.00	.01	.00	.01	.00	.02	.06	.05	.15	.23	.32	.44	.25	.42	.15	.18	.06	.12	.13	1.00
19	.00	.01	.00	.00	.00	.00	.00	.00	.01	.00	.03	.04	.09	.17	.21	.27	.20	.17	.21	.14	.12	.26	.09	1.00
20	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.02	.03	.05	.13	.22	.19	.20	.29	.23	.15	.22	.14	.23	1.00
21	.02	.01	.00	.00	.00	.00	.00	.01	.01	.03	.06	.09	.15	.21	.36	.32	.33	.26	.26	.16	.23	.40	.17	1.00
22	.01	.00	.00	.00	.00	.00	.00	.00	.01	.01	.01	.00	.07	.16	.28	.30	.21	.30	.31	.34	.16	.19	.23	1.00
23	.01	.01	.00	.00	.00	.00	.00	.00	.01	.02	.09	.05	.10	.27	.37	.45	.44	.34	.28	.39	.27	.50	.50	1.00
24	.02	.00	.00	.00	.00	.00	.00	.00	.00	.01	.02	.07	.11	.22	.36	.43	.26	.33	.31	.32	.24	.23	.30	1.00
25	.01	.00	.00	.00	.00	.00	.00	.00	.00	.02	.02	.04	.08	.16	.24	.27	.15	.30	.27	.15	.18	.11	.28	1.00

TABLE [6c]
IRTs per OP Distributions in 1sec. band widths. Rat F10 sessions 133 to 157 on DRL15LH5. IRT > 120 sec. terminates a daily session.

/RESULTS

The 25 sessions produced 7,175 IRTs and the sum of these was 40.1483 hours. Table 6a, b and c show the entire IRT distributions for each of the 25 days as (a) frequencies (b) probabilities and (c) IRTs per OP. The entire output from program "THREE" is enclosed in Computer Appendix 1, and the 0 order frequencies, percentages and 1st order frequencies from program "MESCALINE" can be found in Computer Appendix 2. Figure 6 gives the 1st order distributions for all 6 groups in the 5 sec. classification. Unfortunately there is little information to be obtained from such an analysis. For example, the distribution following $10 \leq IRT < 15$ is almost the same as the distribution after $15 \leq IRT < 20$, except that bursting, i.e. $0 \leq IRT < 5$ does not occur after reinforcement. Figure 7 describes the conditional probabilities for the distributions following IRTs 11, 12, 13, 14, 15, 16, 17 and 23 as these occupy more than 4% of the total IRT output. The distributions after the non-reinforced IRTs less than 15 sec. are all alike with comparable probabilities of reinforcement. Even though the overall probability of bursting is very small (i.e. 4%) the phenomenon described by Sidman (1956a)is verified. That is to say, the probability of burst responding increases as the previous IRT approaches the lower bound of the reinforced interval; but Sidman (1956) found a/

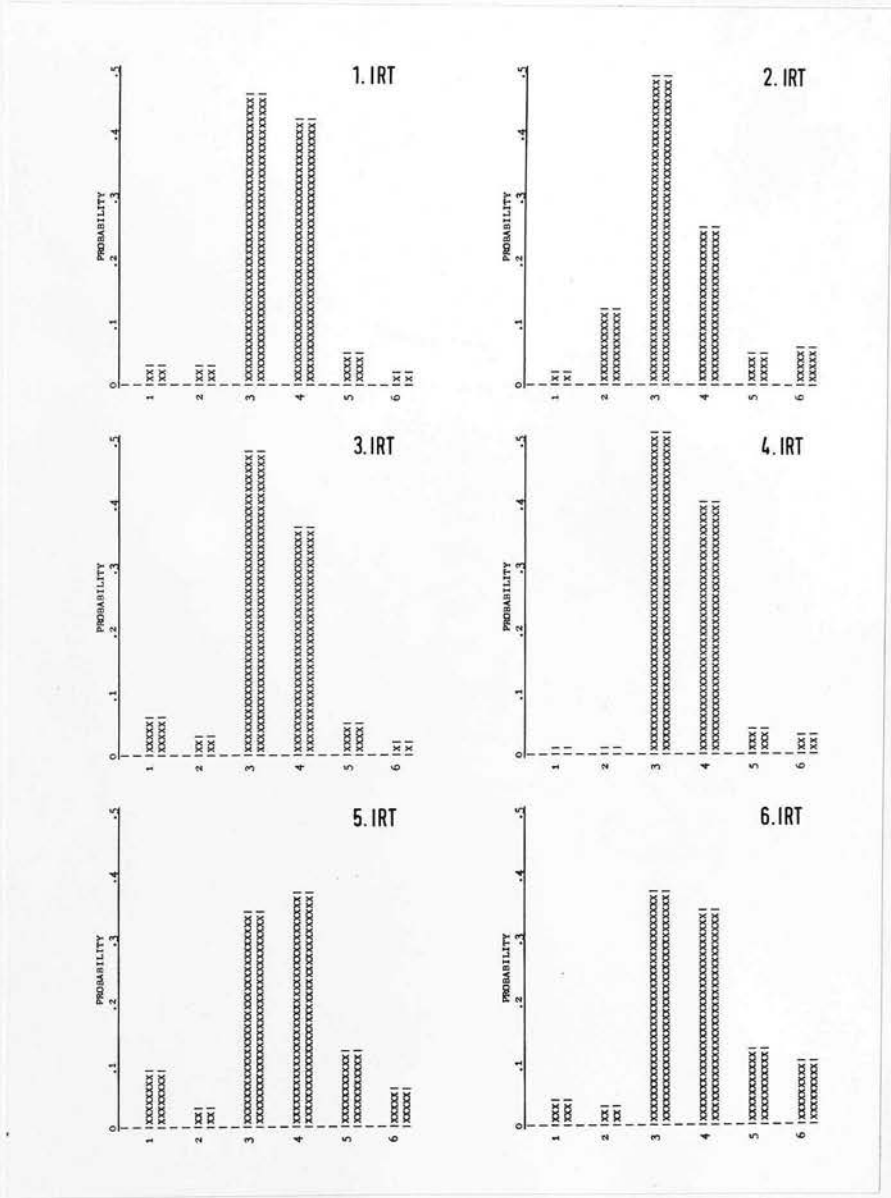


FIGURE [6]

1st ORDER IRT Distributions after classification into 5sec. band widths. Sample F10 (25days) on DRL15LH5. N = 7,175 IRTs.

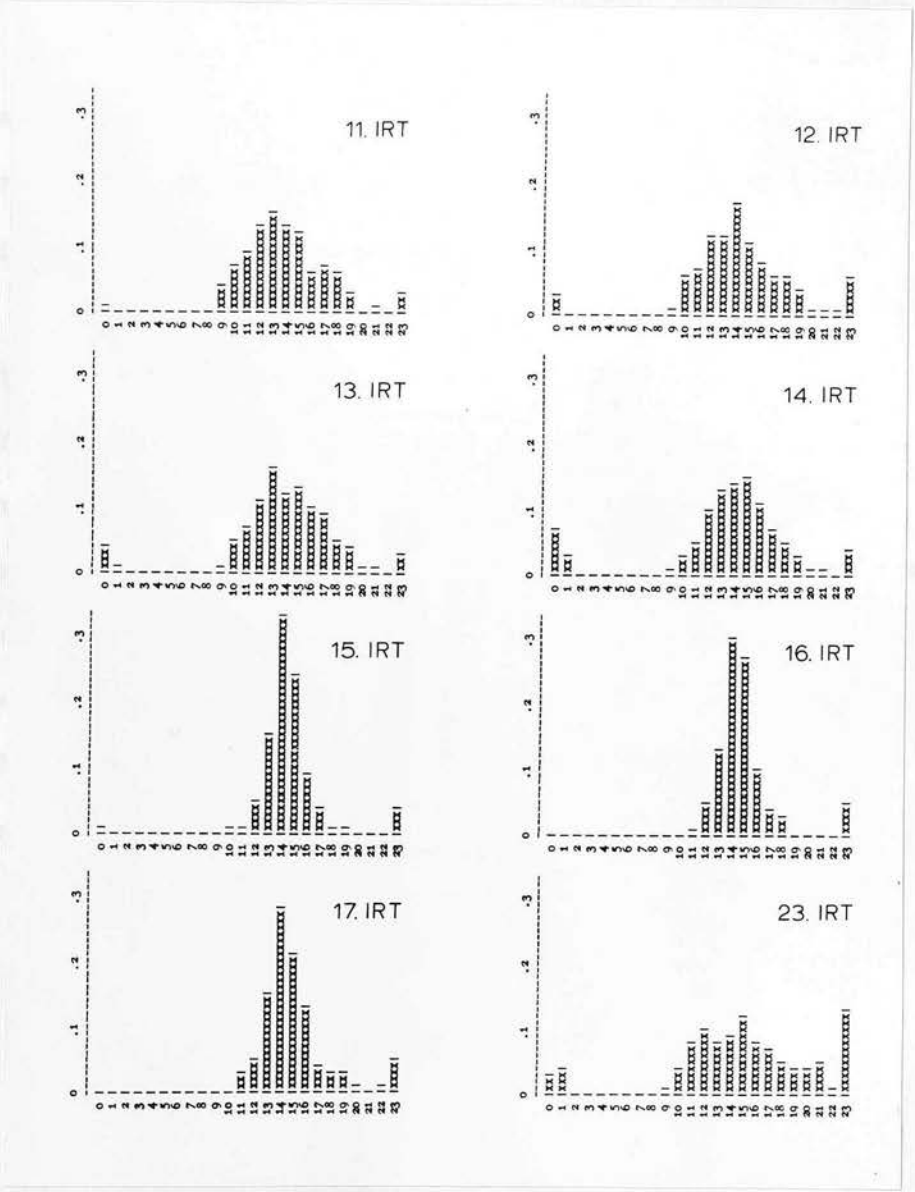


FIGURE [7]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample F10 (25days) on DRL15LH5. N = 7,175 IRTs.

/a very large proportion of small IRTs following reinforcement and this is not the case for the IRT sample from F10. After reinforced IRTs 15, 16 and 17 sec. the characteristic specificity of distribution is evident as in Experiment 4. This marked difference between post-S^R and post-N distributions seems entirely due to the fact that reinforcement was taken not simply to an increase in length of the previous IRT. In comparison with the distributions following IRTs $\geq$ 15 sec. the 23.IRT distribution is rather non-specific. The probability of an IRT $\geq$ 23 is much the same following any IRT, reinforced or not, except for 23.IRT, when it is very high. The properties of the 23.IRT distribution may be due in part to the fact that category 23 tends to occur in trains towards the end of a daily session.

EXPERIMENT 6

Ferraro etal. (1966) have described IS^RT distributions similar to those reported by Farmer and Schoenfeld (1964a) with the modal IS^RT value falling at or near the DRL requirement. This experiment was carried out in order to verify these findings and to look at the serial properties of IS^RT distributions.

METHOD

Three male albino rats F4, F9 and F10 served as subjects and data was sampled after 110 daily sessions on DRL15LH5. Beginning on day 111 the first 101 reinforcements per daily 90 minutes session were recorded as IS^RTs, giving 100 IS^RTs. This was continued for 14 consecutive days for all three animals in order to scrutinize the stability of the IS^RT distribution. IS^RTs were recorded on counters as print-outs were not available. A program "IS^RT ANALYSIS" was written to convert IRT print-out data into consecutive IS^RT information. This program behaves as follows:-

(1) Conversion of IRTs to IS^RTs.

(2) Classification of IS^RTs into 10 sec. band widths from 10 sec. to 110 sec., labelled 1 to 10 with $IS^RTs \geq 110$ sec. classified as 11.

(3) Print-out 0 order. - Frequencies, percentages and IS^RTs per OP.

(4) Print-out 1st order. - Frequencies, IS^RTs per OP and cp's for 2nd member and 1st member of/

/of any pair, in matrix form. First member of a pair given by row number. Second member of a pair given by column number.

Program "IS^{R}T ANALYSIS" is contained in Computer Appendix 4. Continuous IRT sequences were recorded from F9 between days 127-135. A daily session was terminated by an IRT > 120 sec. This sample and the 25 days of F10 described in Experiment 5 were analysed using program "IS^{R}T ANALYSIS" in order to estimate some of the serial properties of IS^{R}Ts.

RESULTS

Table 7a, b and c show the 14 days of consecutive IS^{R}Ts for each animal. Samples from this data are shown in Figure 8. The print-out from program "IS^{R}T ANALYSIS" for both IRT samples i.e. F10 (25 days) and F9 (9 days), are found in Computer Appendix 4. 0 order and 1st order cp's for the 2nd member of any binary combination are reproduced in Figure 9 for sample F10 (25 days). IS^{R}Ts following an IS^{R}T in category 6 or greater, are summarized in one distribution. All these 1st order distributions are exactly the same as the total 0 order distribution. This data is similar for the F9 (9 days) sample which consisted of 2958 IRTs occupying 11.0492 hours. It can be assumed from such a calculation that there are no dependencies greater than 0 order for IS^{R}T data. There is a constant IS^{R}T probability distribution after any reinforcement.

		1	2	3	4	5	6	7	8	9	10	11
	1	41	5	10	10	9	5	4	4	5	3	4
A	2	47	3	10	5	8	7	4	5	1	1	9
	3	38	3	18	13	12	5	1	4	4	0	2
	4	39	6	13	9	6	6	7	3	3	1	7
	5	54	3	8	15	7	4	3	1	3	0	2
B	6	52	6	16	12	5	1	0	3	1	0	4
	7	61	3	10	9	3	4	3	1	0	0	0
	8	50	3	12	13	6	2	5	4	0	1	5
	9	42	4	8	18	7	1	7	6	1	2	4
C	10	48	3	14	6	4	4	2	2	2	1	14
	11	55	7	12	7	4	1	4	5	0	2	3
	12	47	4	12	9	6	7	4	2	4	0	5
	13	54	4	8	7	9	4	5	2	1	1	5
D	14	56	2	15	9	7	2	1	3	1	1	3

TABLE [7a]

O ORDER ISRT Distributions after classification into 10sec. band widths for 14 consecutive daily sessions on DRL15LH5. The first 100 ISRTs of a daily session are sampled. Days A, B, C and D are shown in FIGURE [8]. Rat F4.

		1	2	3	4	5	6	7	8	9	10	11
	1	38	5	14	10	7	4	4	3	3	3	9
A	2	49	6	13	12	4	5	5	1	1	0	9
	3	33	3	9	20	6	8	4	1	6	2	8
	4	35	8	8	21	7	6	2	1	2	1	8
	5	42	6	10	20	9	4	0	1	1	1	5
B	6	42	5	10	10	8	4	4	2	3	2	10
	7	48	2	16	14	2	4	2	4	2	2	4
	8	48	5	6	20	6	3	0	4	2	3	3
	9	32	2	13	12	8	4	3	3	6	4	12
C	10	47	5	10	11	5	4	4	2	1	2	9
	11	38	5	13	16	2	9	5	6	1	1	4
	12	37	7	11	14	9	7	7	3	4	1	0
	13	42	5	11	9	7	5	2	4	7	0	8
D	14	48	6	8	11	8	3	4	2	2	1	8

TABLE [7b]

O ORDER ISRT Distributions after classification into 10sec. band widths for 14 consecutive daily sessions on DRL15LH5. The first 100 ISRTs of a daily session are sampled. Days A, B, C and D are shown in FIGURE [8]. Rat F9.

		1	2	3	4	5	6	7	8	9	10	11
	1	27	5	10	8	11	8	5	4	4	3	15
A	2	33	4	16	17	1	6	4	9	3	0	3
	3	22	8	20	17	10	1	3	6	5	1	6
	4	29	4	25	16	3	10	5	3	2	1	2
	5	29	3	15	13	15	4	3	4	2	3	9
B	6	32	2	22	15	10	5	2	2	1	5	4
	7	28	7	30	13	7	3	5	1	0	1	5
	8	40	8	17	9	9	5	4	3	1	1	3
	9	37	6	22	13	7	7	0	3	0	2	2
C	10	30	7	15	22	9	5	1	3	0	4	4
	11	33	4	20	20	11	2	1	2	0	0	7
	12	28	2	20	16	8	3	2	6	0	0	15
	13	29	4	20	10	9	8	6	3	4	2	4
D	14	38	5	21	14	4	3	5	1	0	1	5

TABLE [7c]

0 ORDER ISRT Distributions after classification into 10sec. band widths for 14 consecutive daily sessions on DRL15LH5. The first 100 ISRTs of a daily session are sampled. Days A, B, C and D are shown in FIGURE [8]. Rat F10.

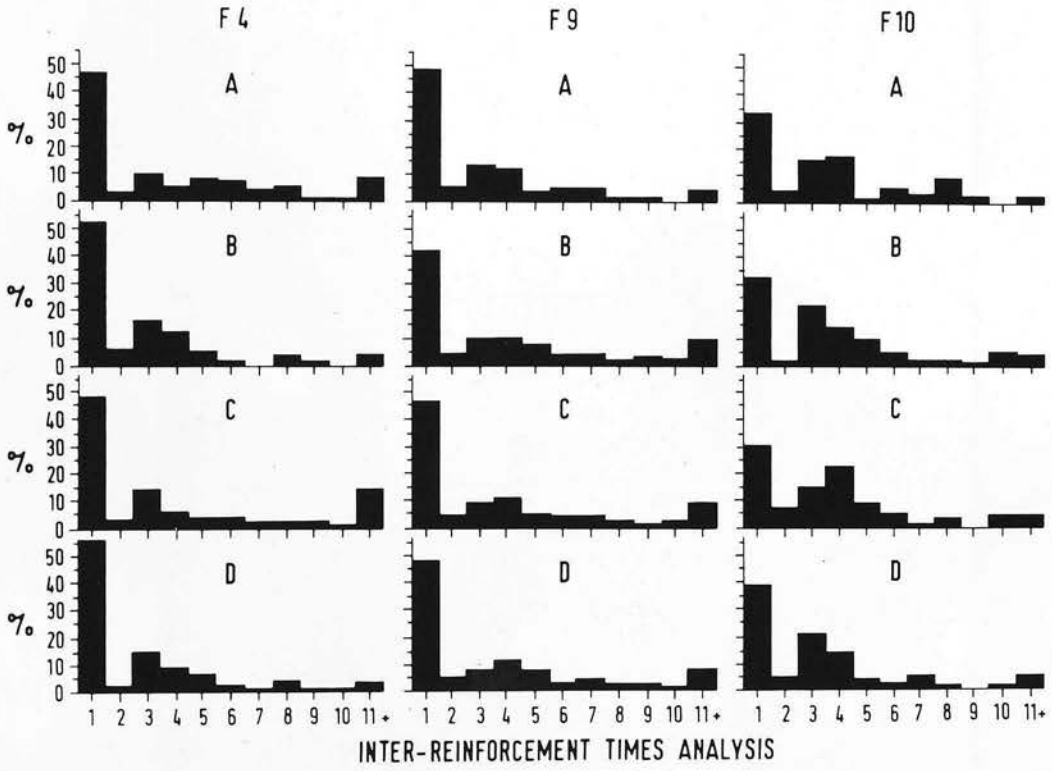


FIGURE [8]

O ORDER ISRT Distributions after classification into 10sec. band widths. Selected every 4th day from TABLE [7] recorded at stability from rats F4,F9 and F10.

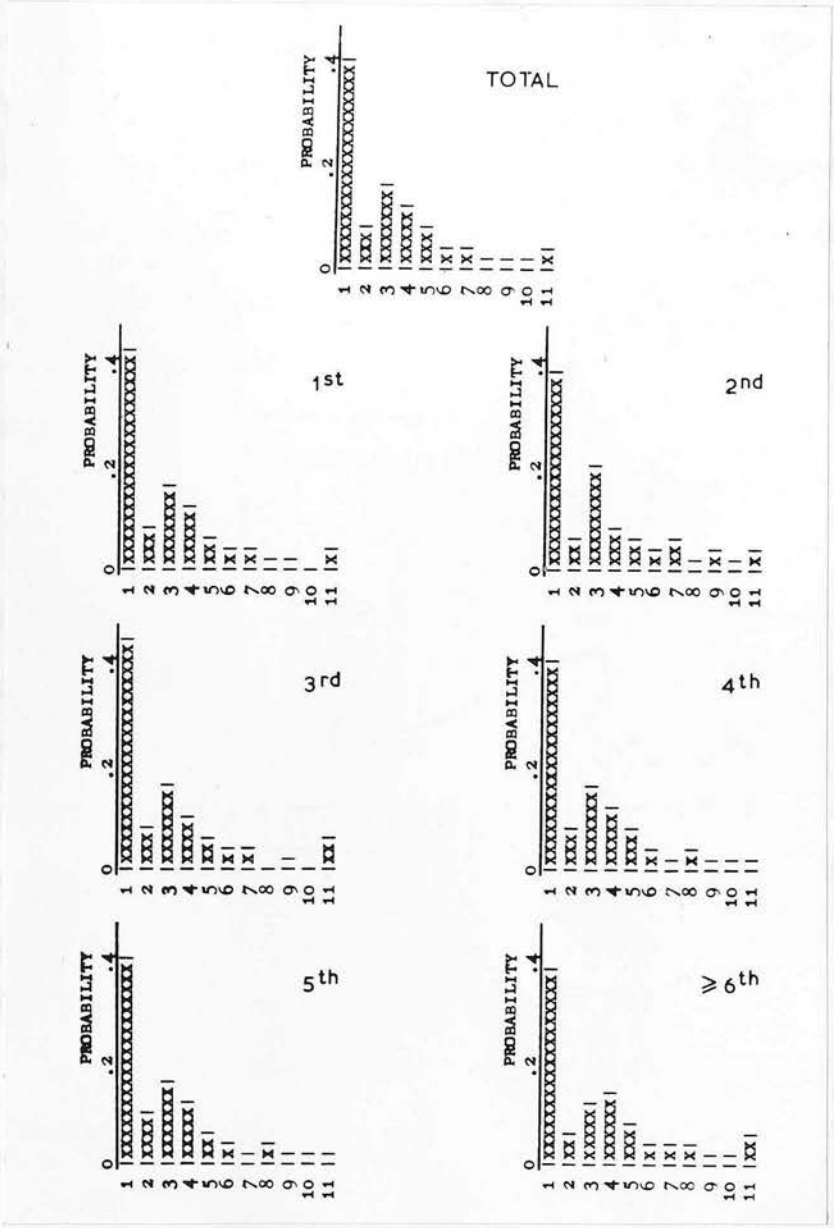


FIGURE [9]

1st ORDER ISRT Distributions after classification into 10sec. band widths. Sample F10 (25days).

EXPERIMENT 7

Kintsch (1965) has shown that except for the latency of the first response after a reinforcement, the mean IRTs of all further responses differed little on both VI40 and VR15. Wertheim (1965) found that on Sidman Avoidance the momentary probability of a response was determined by the time since the last shock. Using reinforcement as a reference point an attempt was made to derive some properties of the ensuing response trains on DRL15LH5.

METHOD

IRT samples F10 (25 days) and F9 (9 days) were used as in Experiment 6. A program "S^R DISTANCE" was written to analyse the constitution of non-reinforced response runs on DRL15LH5, by computing a separate distribution for each position in the run. This program made the following calculations:-

(1) Classification of non-reinforced IRTs into 1 sec. band widths coded from 0 to 22. All IRTs $\geq$ 23 sec. were coded as 23. IRTs $<$ 5 sec. were ignored in computation as the time involved in their emmission is very small in comparison with the overall distribution.

(2) All non-reinforced IRTs are allocated to distributions labelled according to their position after the last reinforcement. This could/

/could take place up to the 30th non-reinforced response of a run.

(3) Print-out. - Frequencies, overall probabilities, IRTs per OP, frequencies expressed as row probabilities and frequencies expressed as column probabilities, all in matrix format. Rows give the position of the non-reinforced IRT. Columns give the distribution for that particular position in the non-reinforced response run.

Program "S^R DISTANCE" is contained in Computer Appendix 5. This program could be altered to perform a similar function for runs of reinforced responses merely by changing the condition "if" on program line 13 to "unless".

RESULTS

Both of these samples, F10 (25 days) and F9 (9 days), were run with both versions of "S^R DISTANCE" incorporating an appropriate "HISTOSTAT RED" routine. The resulting data is enclosed in Computer Appendix 5. Figure 10 gives the probability histograms for sample F9 (9 days) on the "S^R DISTANCE" program. A separate distribution has been calculated for each position in a response run up to the 4th consecutive non-reinforced response after reinforcement. All non-reinforced IRTs further removed than the 4th after/

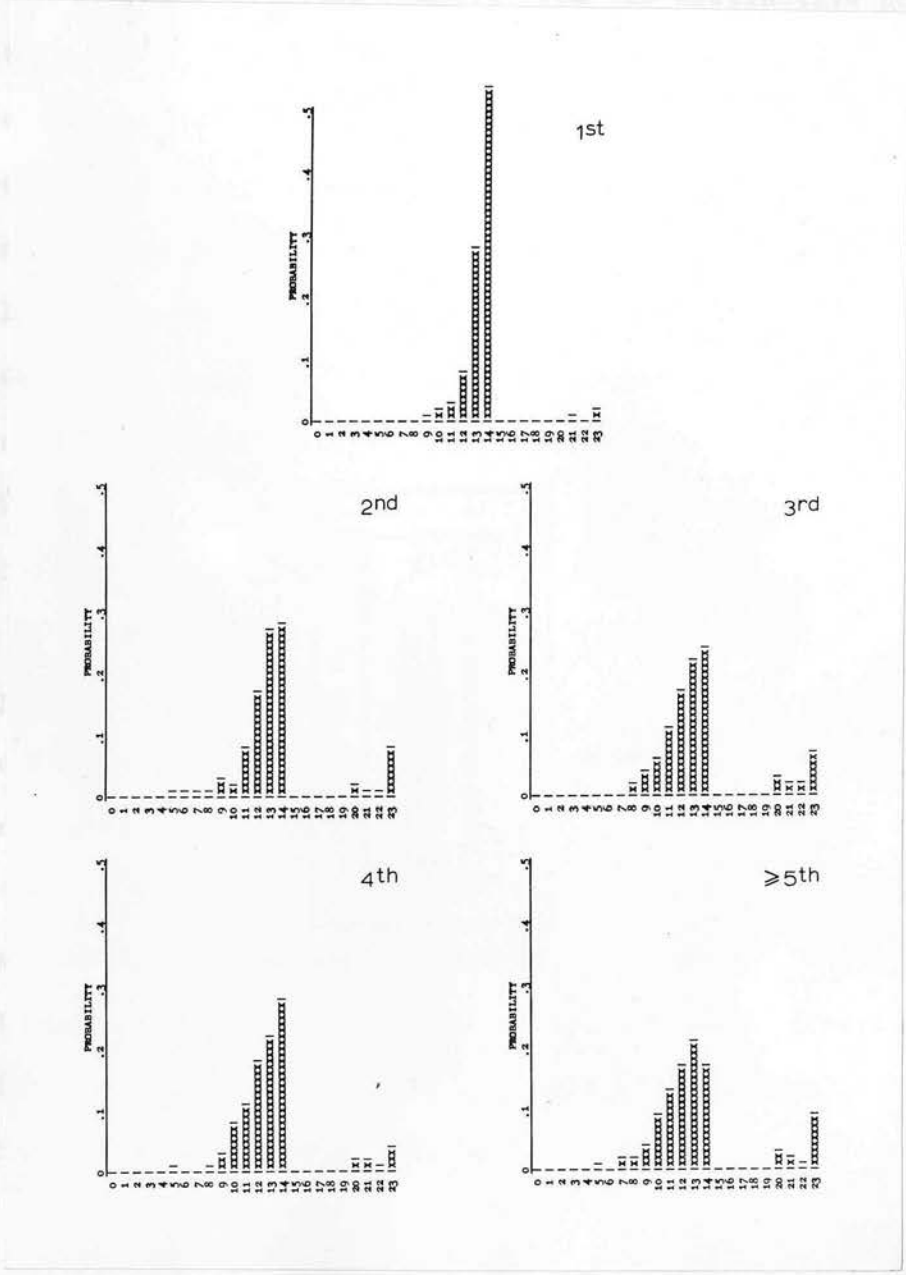


FIGURE [10]

IRT Distributions for each position in a non-reinforced response run (N-RUN). Sample F9 (9days) on DRL15LH5. N = 2,958 IRTs.

/after reinforcement were summarized in one distribution, i.e. $\geqslant$ 5th. Apart from the distinctive post-S^R distribution (1st position in the non-reinforced run), with more than 50% of responses in the 14th second, there appears to be very little deterioration in performance as reinforcement becomes more remote. The complement of this analysis, an examination of reinforcement runs for F9 (9 days), is shown in Figure 11. The 1st position in a reinforcement run produces a distribution which differs markedly from all other positions. A reinforcement following a reinforcement is always more likely to fall in the 15th second, than if it follows a non-reinforced response. The sets of distributions in Figures 10 and 11 demonstrate conclusively that to ascertain the probability of any given IRT we need only be aware of the previous IRT. That is to say serial properties beyond the 1st order may have very little influence upon IRT production. The probabilities used in these histograms are summarized in Table 8 and it can be seen that sample F10 (25 days) entirely confirmed the displayed data for F9 (9 days).

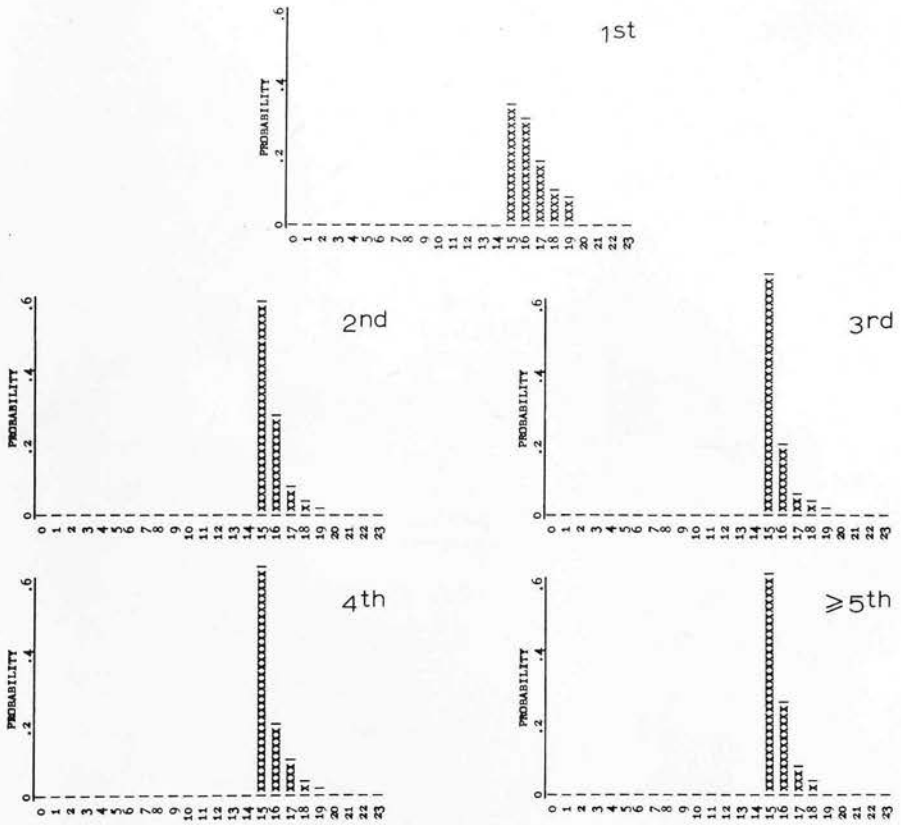


FIGURE [11]

IRT Distributions for each position in a reinforced response run (SR-RUN). Sample F9 (9days).

RUNS OF NON-REINFORCED RESPONSES RAT F10

	5	6	7	8	9	10	11	12	13	14	20	21	22	23+
1	.00	.00	.00	.00	.00	.01	.03	.08	.24	.50	.02	.01	.01	.08
2	.00	.00	.00	.01	.02	.05	.10	.18	.25	.22	.04	.03	.02	.07
3	.00	.00	.01	.01	.03	.08	.09	.17	.20	.24	.04	.03	.01	.09
4	.00	.00	.01	.01	.03	.06	.13	.19	.21	.23	.02	.02	.02	.07
5+	.00	.00	.01	.01	.03	.08	.11	.16	.20	.21	.03	.03	.03	.08

RUNS OF REINFORCEMENT RAT F10

	15	16	17	18	19
1	.35	.25	.19	.13	.08
2	.56	.24	.10	.05	.04
3	.59	.20	.10	.06	.05
4	.59	.22	.06	.10	.04
5+	.56	.24	.09	.07	.04

RUNS OF NON-REINFORCED RESPONSES RAT F9

	5	6	7	8	9	10	11	12	13	14	20	21	22	23+
1	.00	.00	.00	.00	.01	.02	.03	.08	.28	.54	.00	.01	.00	.02
2	.01	.01	.01	.01	.03	.02	.08	.17	.27	.28	.02	.01	.01	.08
3	.00	.00	.00	.02	.04	.06	.11	.17	.22	.24	.03	.02	.02	.07
4	.01	.00	.00	.01	.03	.08	.11	.18	.22	.28	.02	.02	.01	.04
5+	.01	.00	.02	.02	.04	.09	.13	.17	.21	.17	.03	.02	.01	.09

RUNS OF REINFORCEMENT RAT F9

	15	16	17	18	19
1	.34	.30	.19	.09	.08
2	.59	.28	.07	.05	.01
3	.68	.21	.06	.04	.01
4	.64	.21	.09	.04	.02
5+	.63	.26	.07	.04	.00

TABLE [8]

Probability IRT Distributions for all runs of reinforced responses and non-reinforced responses. Samples F9 (9days) and F10 (25days).

EXPERIMENT 8

It can be calculated from the output of program "MESCALINE" for sample F10 (25 days) that the probability of reinforcement after reinforcement $cp(S^R|S^R)$ is 0.4023 whereas the probability of reinforcement after a non-reinforced response $cp(N|S^R)$ is only 0.3562. That is to say a reinforcement is usually more probable if the previous response was reinforced. A further analysis was carried out to see if the probability of S^R in a response run was dependent on the number of previous responses which had been reinforced or non-reinforced.

METHOD

The data used was sample F10 (25 days). Program "PROBE INFORMATIC 3 BY 6TH"(Computer Appendix 6) was written for this purpose and behaved as follows:-

(1) Classification of IRTs into three categories:-

0, $0 \leq IRT < 5$ sec. i.e. Burst

1, $15 \leq IRT < 20$ sec. i.e. Reinforced

2, All remaining IRTs. i.e. Non-reinforced

(2) All overlapping runs of up to 6 IRTs are classified, counted and the conditional probability of the last member is calculated.

(3) Print-out of all identifications, frequencies and conditional probabilities.

RESULTS/

/RESULTS

This program produced over 500 probabilities which are contained in Computer Appendix 6. Table 9 shows the conditional probability of reinforcement given the prior occurrence of up to 5 reinforced or non-reinforced responses. Data are presented for the first 12 days, the 2nd 13 days and all 25 days. The same information is given in graph form in Figure 12. There is a slight tendency for the probability of reinforcement to increase as the length of a reinforcement run progresses. However the probability of reinforcement does not vary with length of non-reinforcement run. The increase of S^R probability with length of S^R run may indicate a slight tendency towards longer serial influences in this schedule.

	F10 1-12		F10 13-25		F10 1-25	
	FREQ.	PROB.	FREQ.	PROB.	FREQ.	PROB.
SR	1328	0.4024	1369	0.3531	2697	0.3758
SR|SR	603	0.4541	481	0.3514	1085	0.4023
SRSR|SR	274	0.4544	167	0.3472	442	0.4074
SRSRSR|SR	128	0.4672	66	0.3952	195	0.4412
SRSRSRSR|SR	61	0.4766	30	0.4545	91	0.4667
SRSRSRSRSR|SR	30	0.4918	14	0.4667	44	0.4835
SR	1328	0.4024	1369	0.3531	2697	0.3758
N|SR	656	0.3626	835	0.3511	1491	0.3562
N N|SR	377	0.3707	472	0.3317	849	0.3482
N N N|SR	217	0.3666	290	0.3318	507	0.3463
N N N N|SR	133	0.3746	167	0.3081	300	0.3352
N N N N N|SR	80	0.3791	105	0.3017	185	0.3321

TABLE [9]

Conditional probability of SR after an N-RUN or SR-RUN up to five consecutive IRTs in length. Sample F10 (25days).

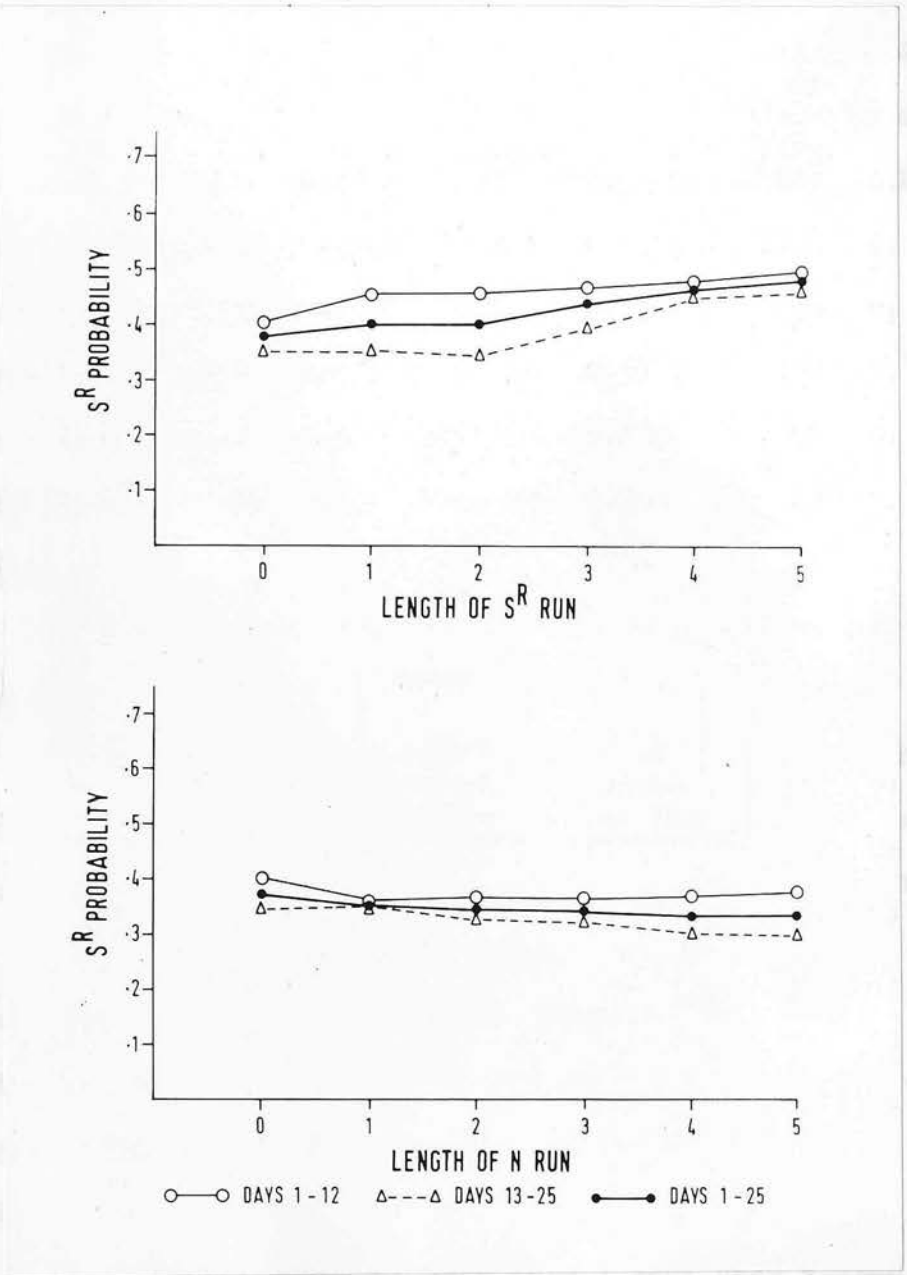


FIGURE [12]

The dependance of SR Probability upon the prior occurrence of an N-RUN or an SR-RUN. Breakdown of Sample F10 (25days).

EXPERIMENT 9

"The transition matrices indicate that for most IRTs, IRT_{n+1} is slightly longer than IRT_n..... hence there is a slow drift of the mode of the momentary response probability distributing toward longer IRTs." Wertheim (1965). Although this finding was reported on a Sidman avoidance baseline, the relationship was examined on DRL15LH5 by calculating the mean and standard deviation for the distribution following any given IRT class.

METHOD

IRT samples from four animals were used in the investigation. F4 (6 days), F9 (9 days), F10 (25 days) and ELVIS (12 days). This data from F4 and ELVIS have not been used in previous experiments. Both samples were taken from consecutive daily sessions on DRL15LH5 (F4, days 141-146 and ELVIS, days 115-126) where a daily session was terminated by an IRT greater than 120 sec. Training conditions were as described in the previous experiments. Program "STATCAT" was used in the calculation and can be explained as follows:-

(1) Classification of IRTs into 1 sec. band widths coded from 0 to 22. All IRTs$\geq$23 sec. were coded as 23.

(2) IRTs$<$ 5 sec. or$>$25 sec. were neglected. This decision was taken because in 0 order distribution/

/distribution both of these categories form individual peaks distinct from the characteristic temporal distribution. Thus it might be assumed that they are mediated by some process other than that producing the normal IRT distribution.

(3) Calculation and print-out of frequency, proportion, mean and standard deviation for the distribution following each 1 sec. band from 5 to 23.

This program can be found in Computer Appendix 7.

RESULTS

Samples F4 (6 days) produced 2008 IRTs and occupied 7.5221 hrs. Sample ELVIS (12 days) produced 3657 IRTs and occupied 13.5381 hours. Figure 13 gives the first order IRT histograms for F4 (6 days) produced by program "HISTOSTAT RED". In Figures 14 and 15 can be found similar data for samples ELVIS (12 days) and F9 (9 days). Histograms for F10 were previously shown in Figure 7. All these samples follow the established pattern, demonstrating a greater precision of discrimination after reinforcement. Figure 16 gives the 1st order means after IRTs 10-19 for all four samples and Figure 17 provides the standard deviations. There is a definite upward trend in 1st order means. On average IRT_{n+1} tends to be greater than IRT_n. The standard deviations reflect the gross differences in the distributions after reinforced/

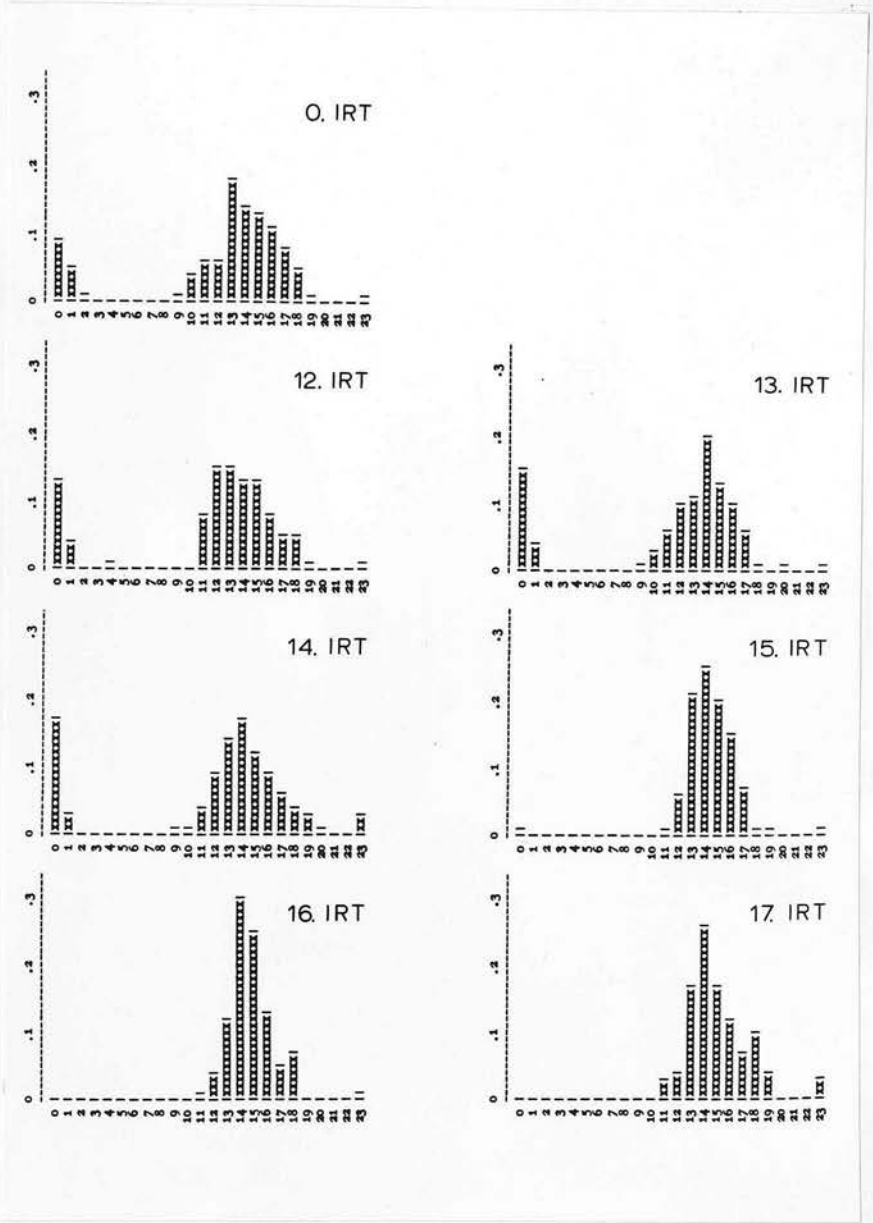


FIGURE [13]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample F4 (6days) on DRL15LH5. N = 2,008 IRTs.

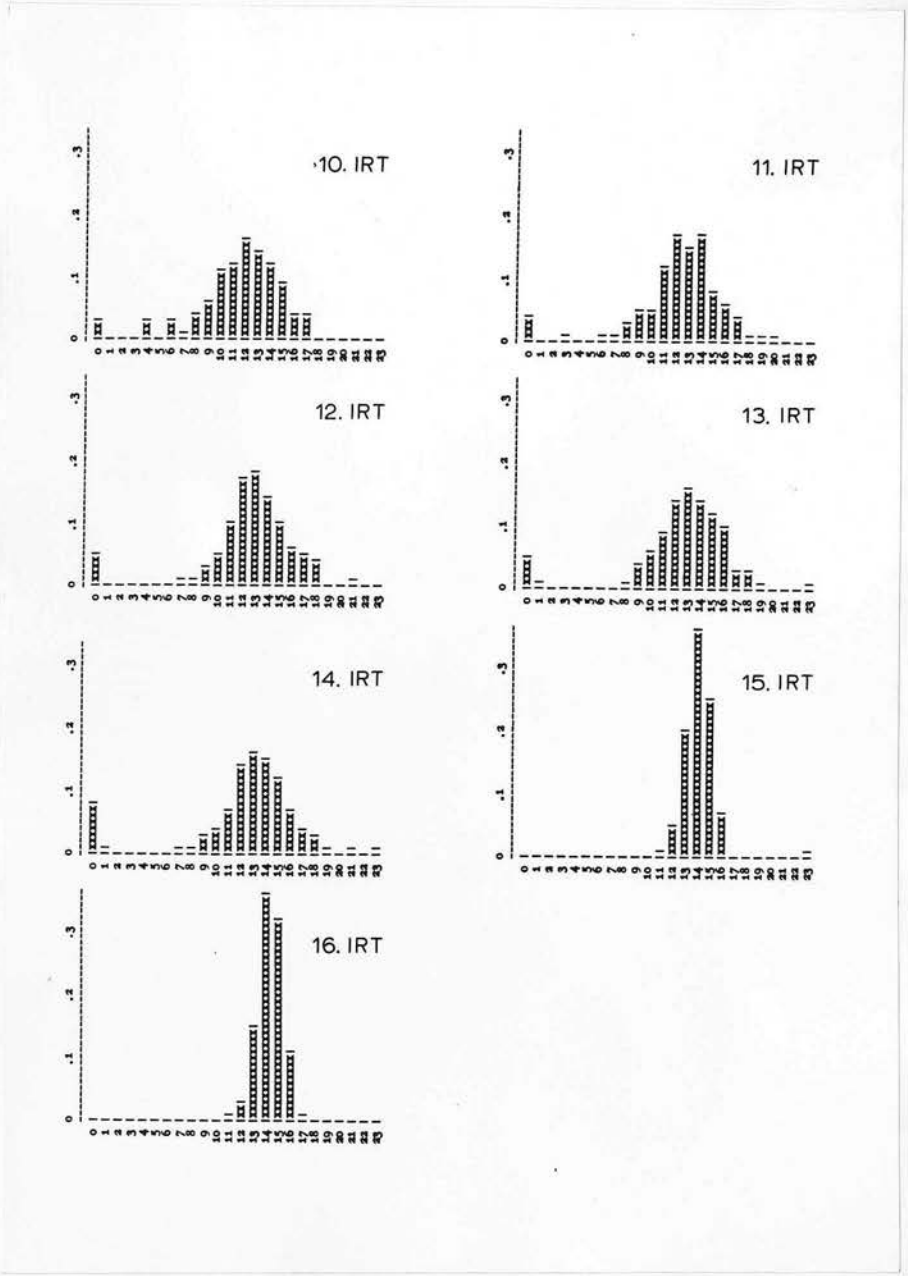


FIGURE [14]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample ELVIS (12days) on DRL15LH5. N = 3,657 IRTs.

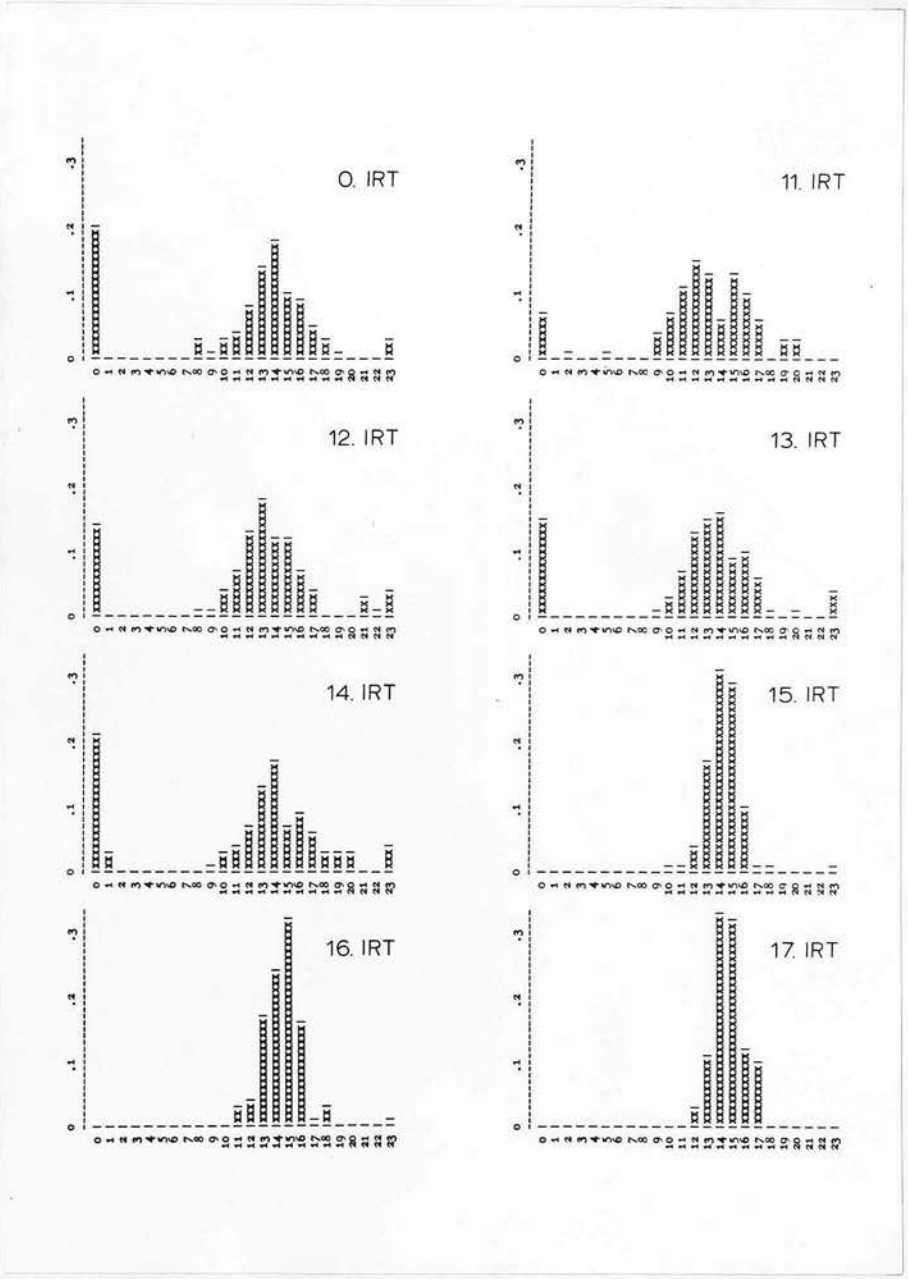


FIGURE [15]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample F9 (9days).

/reinforced and non-reinforced responses. There is a drop of around one standard deviation between the post-14 and post-15 IRT distributions. In comparison with this large change, the differences in means do not reflect the transition from the non-reinforced IRTs into the LH period. This is a good reminder of how certain statistics can obliviate the truth for though the 1st order means progress upwards in a continuous fashion, the standard deviations show a remarkable discontinuity between the 14.IRT and 15.IRT distributions. Tables 10a, b, c and d contain the calculated statistics from program "STATCAT".

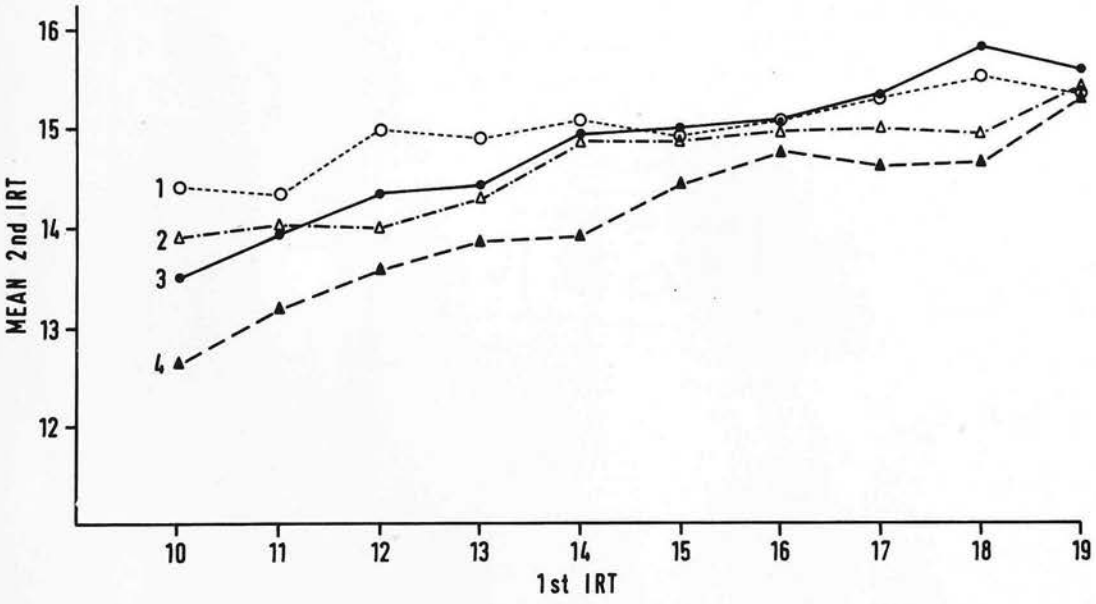


FIGURE [16]

Means of the 1st ORDER Distributions after classification into 1sec. band widths. 4 samples.

1 - Sample F10 (25days)
2 - Sample F9 (9days)
3 - Sample F4 (6days)
4 - Sample ELVIS (12days)

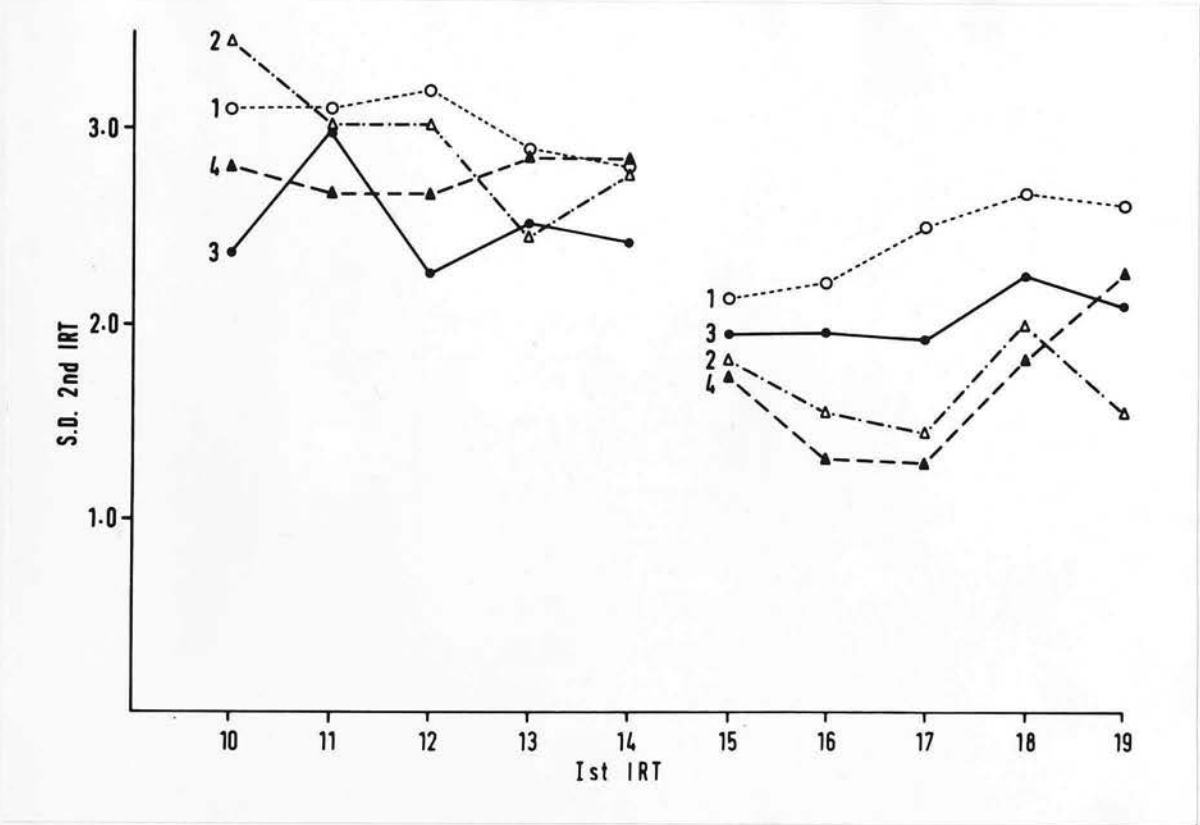


FIGURE [17]

Standard Deviations of the 1st ORDER Distributions after classification into 1sec. band widths. 4 samples.

1 - Sample F10 (25days)
2 - Sample F9 (9days)
3 - Sample F4 (6days)
4 - Sample ELVIS (12days)

IRT	FREQUENCY	PROPORTION	MEAN	STANDARD DEVIATION
5	9	0.0013	12.7222	2.4321
6	6	0.0008	12.4667	1.9720
7	17	0.0024	13.1588	5.3886
8	33	0.0046	14.3000	3.5956
9	81	0.0113	14.1247	3.2349
10	200	0.0279	14.4115	3.1009
11	318	0.0443	14.3220	3.0942
12	576	0.0803	15.0028	3.1773
13	955	0.1331	14.9062	2.8987
14	1377	0.1919	15.1007	2.8280
15	1186	0.1653	14.9250	2.0030
16	654	0.0911	15.1391	2.0865
17	416	0.0580	15.3139	2.5272
18	271	0.0378	15.5653	2.7866
19	170	0.0237	15.3529	2.7247
20	120	0.0167	15.6642	3.1818
21	94	0.0131	15.4479	3.4434
22	72	0.0100	16.5583	3.5484
23+	56	0.0078	15.6500	3.4201

TABLE [10a]

0 ORDER Frequency and Proportion and 1st ORDER Mean and Standard deviation in 1sec. band widths. Sample F10 (25days).

IRT	FREQUENCY	PROPORTION	MEAN	STANDARD DEVIATION
5	8	0.0027	13.4250	4.7817
6	2	0.0007	7.7000	2.0000
7	12	0.0041	15.0000	4.0141
8	21	0.0071	14.1810	2.8528
9	40	0.0135	13.1700	3.4921
10	76	0.0257	13.9092	3.4580
11	131	0.0443	14.0221	3.0441
12	229	0.0774	14.0035	3.0314
13	407	0.1376	14.2850	2.4522
14	544	0.1839	14.8914	2.8024
15	465	0.1572	14.8703	1.8035
16	277	0.0936	14.9823	1.5567
17	132	0.0446	15.0576	1.4283
18	67	0.0227	14.9642	2.0155
19	43	0.0145	15.4326	1.5611
20	31	0.0105	16.5226	3.2574
21	24	0.0081	16.0417	3.1604
22	16	0.0054	14.1437	3.7261
23+	14	0.0047	14.4286	2.9232

TABLE [10b]

0 ORDER Frequency and Proportion and 1st ORDER Mean and Standard deviation in 1sec. band widths. Sample F9 (9days).

IRT	FREQUENCY	PROPORTION	MEAN	STANDARD DEVIATION
5	4	0.0020	11.5000	3.9617
6	3	0.0015	13.7333	2.2691
7	5	0.0025	12.3600	3.6308
8	5	0.0025	14.1400	1.8216
9	17	0.0085	14.0118	3.1288
10	35	0.0174	13.5114	2.3454
11	79	0.0393	13.9608	3.0266
12	163	0.0812	14.3374	2.2520
13	296	0.1474	14.4206	2.5206
14	375	0.1868	14.9552	2.4252
15	308	0.1534	15.0192	1.9416
16	204	0.1016	15.1299	1.9557
17	121	0.0603	15.3628	1.9250
18	75	0.0374	15.8667	2.2516
19	32	0.0159	15.7469	2.1085
20	17	0.0085	15.1765	2.0305
21	5	0.0025	15.0400	2.1416
22	6	0.0030	14.8500	2.0823
23+	5	0.0025	14.4400	2.1247

TABLE [10c]

0 ORDER Frequency and Proportion and 1st ORDER Mean and Standard deviation in 1sec. band widths. Sample F4 (6days).

IRT	FREQUENCY	PROPORTION	MEAN	STANDARD DEVIATION
5	17	0.0046	12.0471	2.6059
6	32	0.0088	10.9594	2.5855
7	37	0.0101	11.6811	3.1550
8	57	0.0156	12.0649	3.8167
9	97	0.0265	12.8784	2.9828
10	160	0.0438	12.6581	2.8022
11	271	0.0741	13.1989	2.6695
12	421	0.1151	13.5727	2.6690
13	575	0.1572	13.8574	2.8636
14	715	0.1955	13.8915	2.7887
15	526	0.1438	14.4717	1.7252
16	249	0.0681	14.7715	1.3196
17	103	0.0282	14.6359	1.2927
18	69	0.0189	14.6768	1.8201
19	35	0.0096	15.3257	2.2691
20	19	0.0052	15.3000	2.4441
21	22	0.0060	15.4045	2.9463
22	10	0.0027	16.2700	4.6085
23+	10	0.0027	13.7800	1.7337

TABLE [10d]

0 ORDER Frequency and Proportion and 1st ORDER Mean and Standard deviation in 1sec. band widths. Sample ELVIS (12days).

E X P E R I M E N T 10

Using the techniques of autocorrelation and spectral analysis Weiss etal. (1966) found evidence of both long-term and extremely short-term fluctuations in IRTs at stability on DRL20 secs. These techniques point to the reality of serial dependencies on such schedules but do very little to identify them. This experiment describes an application of the averaged uncertainty technique reported by Frick and Miller (1951) in an attempt to verify the existence of the 1st order dependencies already established. Following the initial development of information theory by Wiener (1948) and Shannon (1948), Miller and Frick (1949) introduced the methods to the psychological literature. Since then a great deal of research and several books have been devoted to exploring the implications of information theory as a model for certain aspects of human and animal behaviour and to examining, discussing and extending the statistical properties of the measures provided by information theory. The treatments of Attneave (1959), Luce (1960), Garner (1962) and Binder and Wolin (1964) have provided very complete surveys of the work relevant to the behavioural sciences. Frick and Miller (1951) calculated the averaged uncertainty for a two response category situation up to 3rd order dependencies and demonstrated that the uncertainty function decreased as/

	1	2	3	4
0 ORDER	0.45926415	0.45639177	0.44103540	0.40364362
1ST ORDER	0.45872035	0.44661510	0.42553290	0.39826852
2ND ORDER	0.45875250	0.44560745	0.42441872	0.39784163
3RD ORDER	0.45859590	0.44339079	0.42268405	0.39613301
4TH ORDER	0.45796329	0.44181803	0.42210689	0.39534089
5TH ORDER	0.45753443	0.43822904	0.41857430	0.39253862
6TH ORDER	0.45613366	0.43461154	0.41398713	0.38656121
7TH ORDER	0.45279890	0.42050848	0.40510759	0.37849462

TABLE [11]

Averaged Uncertainties up to 7th ORDER dependencies.

1 - Sample F10 (25days)
2 - Sample F4 (6days)
3 - Sample F9 (9days)
4 - Sample ELVIS (12days)

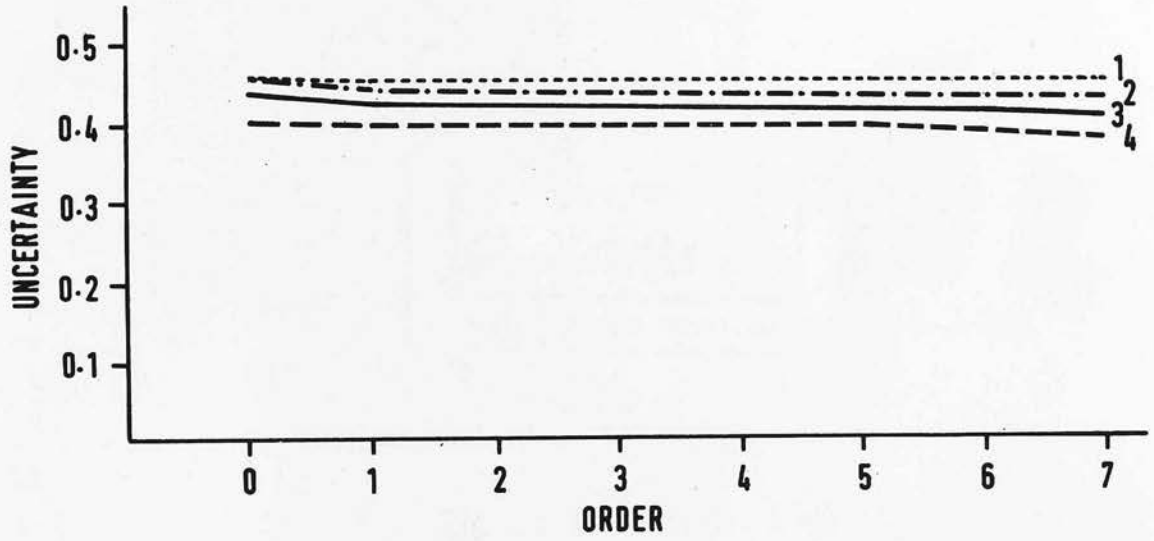


FIGURE [18]

Averaged Uncertainties up to 7th ORDER dependencies.

1 - Sample F10 (25days)
2 - Sample F4 (6days)
3 - Sample F9 (9days)
4 - Sample ELVIS (12days)

/as larger sequences of responses were considered.

METHOD

The four samples F4 (6 days), F9 (9 days), F10 (25 days) and ELVIS (12 days) were used as in Experiment 9. Program "INFORMAT B15 8TH ORDER" was written to calculate averaged uncertainties up to 7th order (i.e. up to runs of eight responses) for two categories, reinforced responses and non-reinforced responses. The program is contained in Computer Appendix 8 and behaved as follows:-

(1) Classification of all IRTs into two categories reinforced responses and non-reinforced responses.

(2) Computation and print-out averaged uncertainty function up to 7th order.

RESULTS

The 8 uncertainty values for each of the four samples are contained in Table 11 and displayed in graph form in Figure 18. Each function is almost a straight line, parallel to the 'x' axis. Little information is obtained from such an analysis though the drop in uncertainty may be slightly greater between 0 and 1st order than between all other consecutive values. So this particular technique does not reveal any serial dependencies on DRL15LH5 but we already know that such interactions are indeed present.

E X P E R I M E N T 11

Early in the training of rat F9 it became apparent that he was engaging in a form of collateral licking. An attempt was made to measure this behaviour by placing a microphone in close proximity to the dipper mechanism and recording the sounds produced. This procedure showed that the animal was gnawing or scraping the rim of the dipper shield rather than licking it. The activity was recorded on magnetic tape throughout the entire data sampling period and later fed into a Grass Polygraph for more detailed analysis. Figure 19 shows a sample of this polygraph record. Reinforced responses (S^R), non-reinforced responses (N) and collateral gnawing (C) were easily distinguishable on both auditory and graphic records. The most striking feature of the collateral behaviour was that it occurred after every reinforcement taken and almost never followed a non-reinforced response. There was a conspicuous lack of any stereotyped activity after non-reinforced responses. Post-S^R IRTs were completely occupied by spurts of gnawing interspersed with unusual and irregular head movements. Subsequent investigation revealed that F10 also indulged in a type of gnawing after reinforcement. This activity took place at a point opposite to that used by F9 on the dipper shield. Unlike F9 the form of gnawing used by F10 was continuous, completely occupying the time between the release of the dipper arm and the next lever press. This/

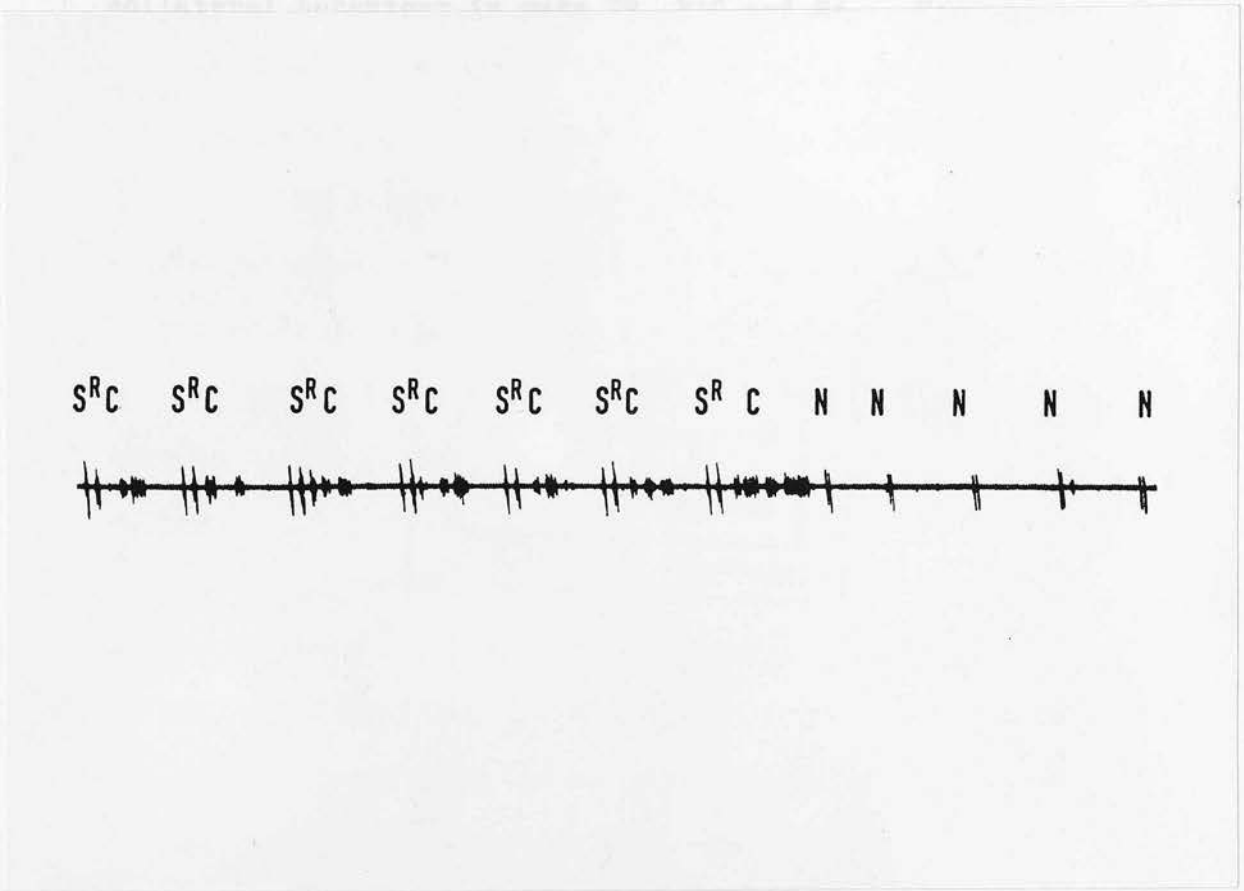


FIGURE [19]

Polygraph record of collateral behaviour and lever-pressing recorded by a microphone placed in the experimental chamber. Reinforcement (SR) is indicated by two large deflections caused by the up and down impacts of the dipper arm. Non-reinforced responses (N) produced smaller deflections due to the microswitch operation. (C) is the collateral gnawing activity.

/This post-S^R collateral has previously been described for rat E4 in Experiment 4. The 1st order IRT distributions seem to reflect the existence of post-S^R collateral behaviour in rats F9, F10 and E4. However, samples from E1, E3, F4 (6 days), ELVIS (12 days) and RINGO (8 days), (this rat will be used in Experiment 12), show the same improved temporal discrimination after reinforcement and no identifiable collateral behaviour would appear to be involved. An attempt was made to block the gnawing behaviour of F9 and F10 by the application of quinine to the dipper shield.

METHOD

The subjects of this experiment were F9 and F10. The procedure was exactly as in Experiment 4. Quinine paste was dried off from the dipper shield after three applications, and all IRTs were recorded in sequence. It was intended in this manipulation to continue quinine treatments on consecutive days up to 9 sessions and then compare with a control sample of comparable duration. Quinine sessions were terminated by the first IRT 120 sec. occurring at least 75 minutes after the beginning of a session.

RESULTS

Two attempts were made on alternate days to disrupt the behaviour of rat F10 but on the occasion of each initial contact with the quinine the animal ceased to lever-press for up to 90 minutes, whereupon the session was terminated./

/terminated. This animal died after the loss of an upper incisor several days later, so the quinine treatment could not be continued. However the quinine was successful in abolishing gnawing behaviour in rat F9. The treatments were commenced on day 139 four days after the termination of sample F9 (9 days) on day 135. Daily training was continued on the three intervening days 136-138, but behaviour could not be sampled due to print-out failure. Auditory analysis showed that gnawing behaviour had been almost completely suppressed, but the unusual head movements were continued in the region of the dipper shield. Days 3 and 7 of quinine treatment could not be sampled due to print-out failure so the sample was only 7 sessions long. Total IRTs recorded were 2280 and the "HISTOSTAT RED" output is produced in Figure 20. When this data is compared with the control sample F9 (9 days) in Figure 15 we can see that there is a marked change in post-S^R distributions induced by the quinine treatments. The decrease in standard deviation is still evident but the mean IRT is shifted to the left thus decreasing the probability of S^R after S^R. Analysis by program "PROBE INFORMATIC 3 BY 6TH" is summarized in Figure 21. (Raw data in Table 12). As in Experiment 8 for F10 (25 days), the probability of a reinforcement increases with length of previous S^R run. This increment is absent when collateral gnawing is blocked by quinine application and the sequential properties of an "S^R" run become similar to those of an "N" run. This change/

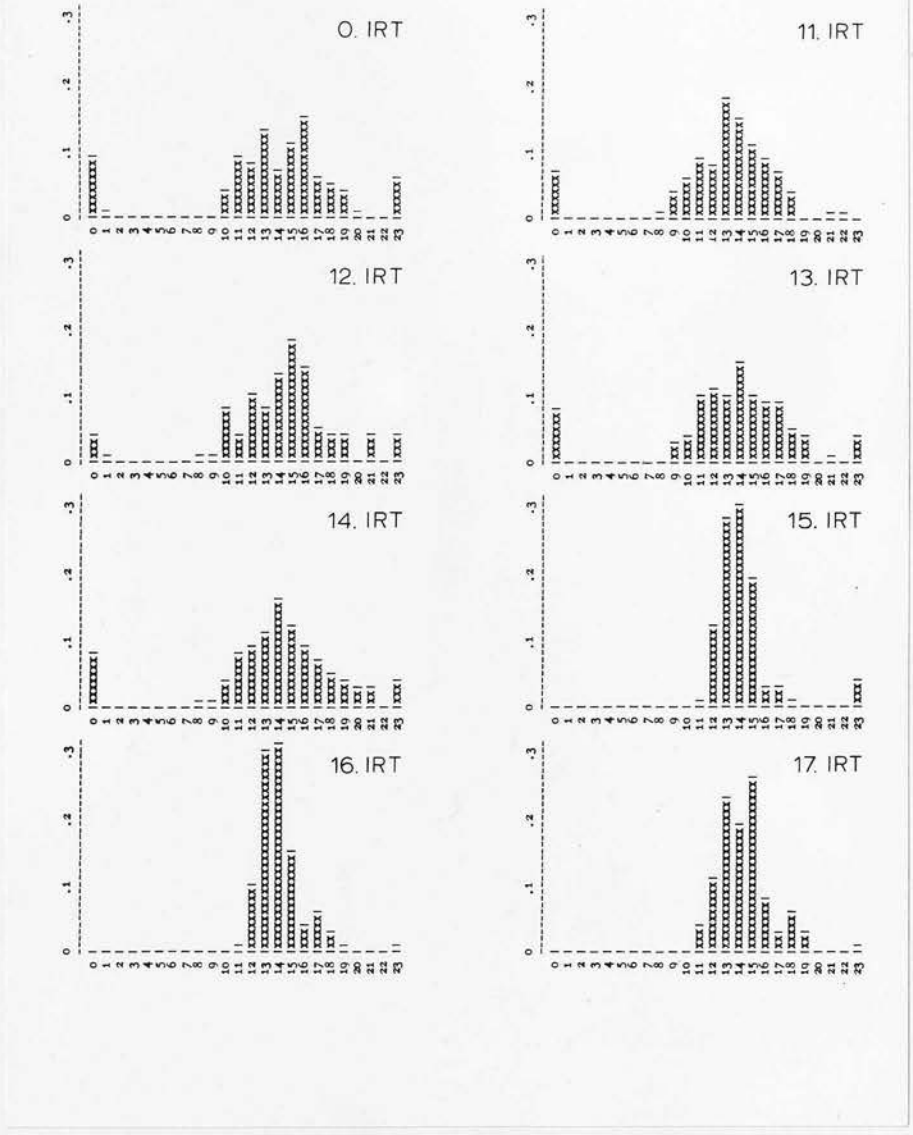
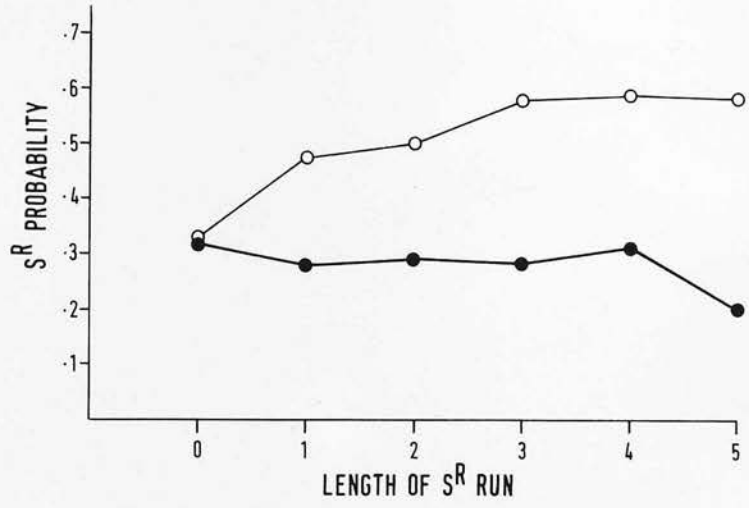


FIGURE [20]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample F9 (QUININE 7days) on DRL15LH5. N = 2,280 IRTs.



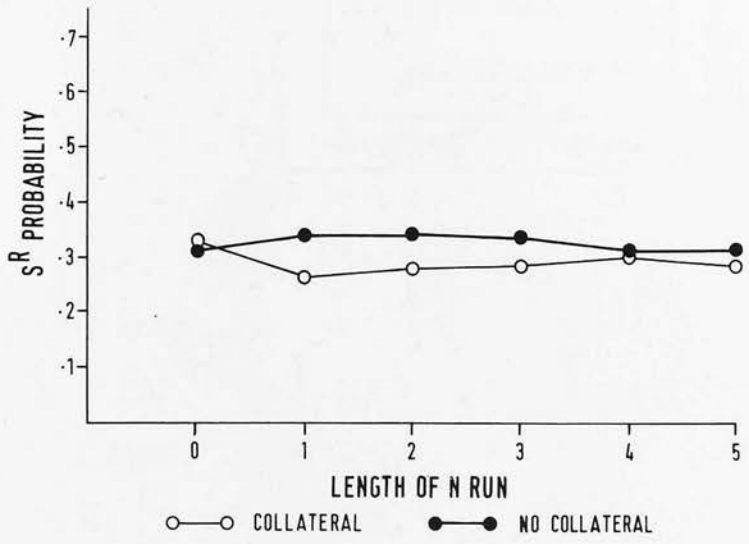


FIGURE [21]

The dependence of SR Probability upon the prior occurrence of an N-RUN or an SR-RUN. 2 Samples.
1 - COLLATERAL Sample F9 (9days)
2 - NO COLLATERAL Sample F9 (QUININE 7days)

	F9 COLLATERAL		F9 NO COLLATERAL	
	FREQ.	PROB.	FREQ.	PROB.
SR	984	0.3325	733	0.3214
SR|SR	469	0.4766	202	0.2756
SRSR|SR	236	0.5032	58	0.2871
SRSRSR|SR	137	0.5805	16	0.2759
SRSRSRSR|SR	81	0.5912	5	0.3125
SRSRSRSRSR|SR	47	0.5802	1	0.2000

SR	984	0.3325	733	0.3214
N|SR	428	0.2623	484	0.3396
N N|SR	260	0.2787	285	0.3421
N N N|SR	157	0.2844	165	0.3354
N N N N|SR	100	0.3021	92	0.3098
N N N N N|SR	55	0.2850	59	0.3122

TABLE [12]

Conditional probability of SR after an N-RUN or SR-RUN up to five consecutive IRTs in length. 2 samples.

1 - COLLATERAL Sample F9 (9days)
2 - NO COLLATERAL Sample F9 (QUININE 7days)

/change may be due to the fact that gnawing was only a single component of the collateral chain after S^R. The disappearance of gnawing may have shortened this chain-mediated IRT so that the post-S^R distribution changed in mean value though not in variance.

E X P E R I M E N T 12

We have already observed in Experiment 5, Figure 7, that as non-reinforced IRTs approach the lower bound of the LH period the probability of bursting increases (Sidman 1956a). However, none of the 1st order "HISTOSTAT RED" outputs described herein support the finding by Sidman (1956) that an appreciable quantity of bursting occurs after reinforcement. The 1st order distributions in Figure 15 for F9 (9 days) (with an overall probability of bursting greater than 10%) also demonstrate the Sidman effect. The analysis carried out in this experiment was intended to examine this phenomenon but for dependencies much longer than the 1st order calculations of Sidman.

METHOD

Two DRL15LH5 samples were used, F9 (9 days) and RINGO (8 days). Sample Ringo (8 days) has not been previously described and produced 2572 IRTs between sessions 96 and 103 of training on DRL15LH5 with more than 14% bursting. Four new programs were used "TRIAD DIG", "TRIAD", "DISTANCE NAP" and "REINFORCEMENT NAP" and they behave as follows:-

A) "TRIAD DIG". Computer Appendix 9.

(1) Classification of IRTs into 1 sec. band widths from 0 to 22 sec. All IRTs $\geq$ 23 sec. were coded as 23.

(2) Print-out 2nd order frequencies and conditional probabilities in matrix form. 1st member of a triad given at top of Matrix, 2nd member given by row number and 3rd member by column number. Conditional probability refers to the probability of the 3rd member of a triad, given the identity of the first two members.

B) "TRIAD". Computer Appendix 9.

(1) Classification of IRTs into 14 band widths coded from 0 to 13. $0 \leq IRT < 5$ sec. coded as 0. $11 \leq IRT < 23$ coded in 1 sec. intervals as (IRT-10). $5 \leq IRT < 11$ coded in category 13.

(2) Print-out 2nd order frequencies and conditional probabilities in matrix form. 1st member of a triad given at top of matrix, 2nd member given by row number and 3rd member by column number. (As in "TRIAD DIG"). This program is merely a version of "TRIAD DIG" which produces a more parsimonious data output.

C) "DISTANCE NAP". Computer Appendix 10.

(1) Classification of IRTs into three categories, burst, reinforced and non-reinforced. In this program bursting is defined as any run of IRTs, none of which exceeds 5 sec.

(2) Identification of runs of non-reinforced responses and classification according to length of run./

/run. Burst responses are ignored in the estimation of N runs.

(3) Identification of N runs followed by a burst. Burst responding is ignored if it occurs in that N run, prior to the identified burst.

(4) Print-out of the total frequency of all N runs up to 30 in length and the number of such runs which are followed by bursting.

D) "REINFORCEMENT NAP". Computer Appendix 11.

(1) Response classification as in "DISTANCE NAP".

(2) Identification of all sequences of the form N.X.N. where X is a run of reinforced responses of any length, from 1-30. Burst responding is completely ignored in this classification.

(3) Identification of all sequences of the form N.X.N.B. where X is a run of reinforced responses of any length, from 1-30. Burst responding is completely ignored in any position of the sequence other than the last. Calculations from "PROBE INFORMATIC 3 BY 6TH" and "MESCALINE" were also used in this experiment.

(4) Print-out of the total frequency of all S^R runs up to 30 in length and the number of such runs which are followed by the pair N.B.

RESULTS/

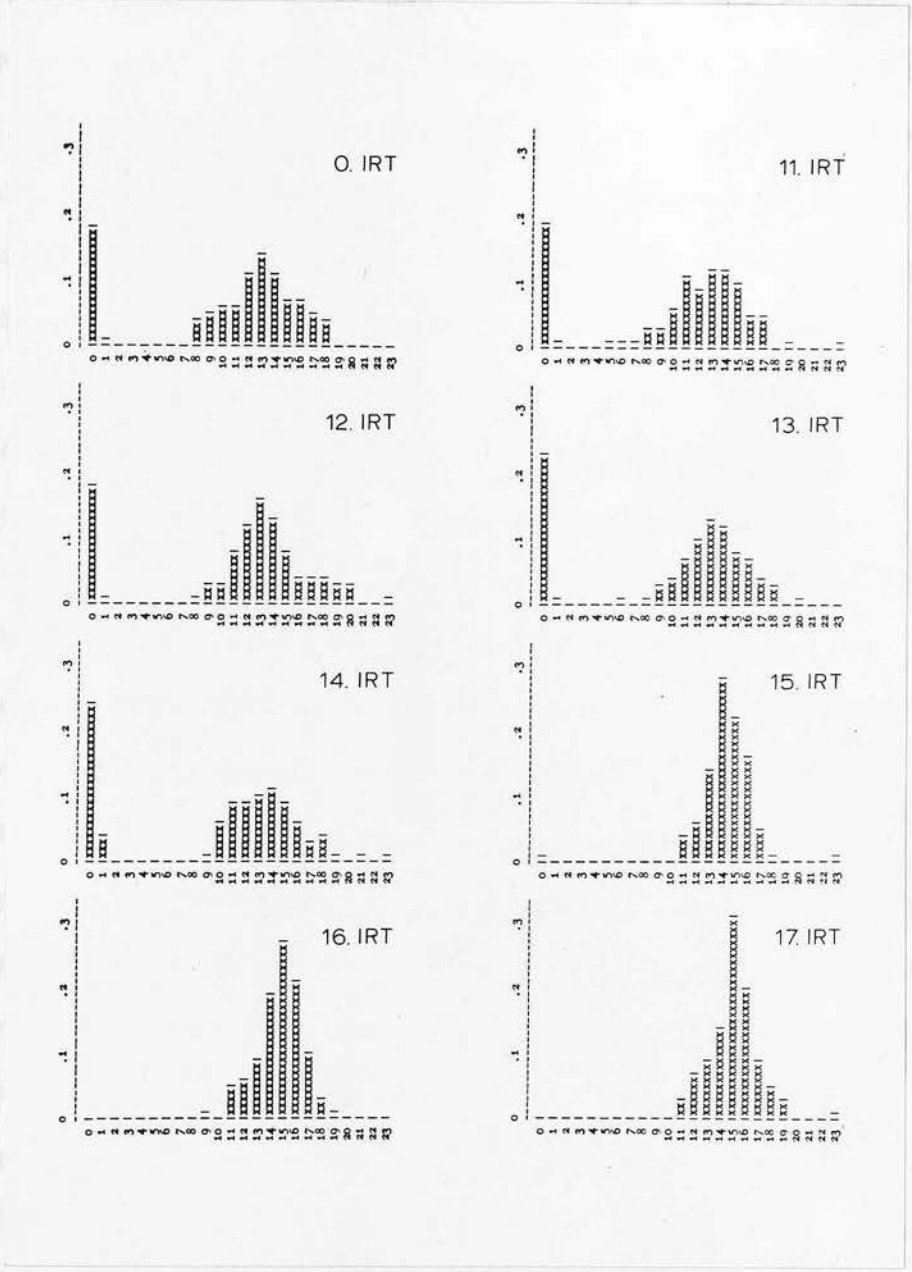


FIGURE [22]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample RINGO (8days) on DRL15LH5. N = 2,572 IRTs.

RESULTS

Figure 22 gives the "HISTOSTAT RED" output for sample RINGO (8 days). The relationship between burst responding and the preceding IRT as demonstrated by Sidman (1956) was again evident from this sample. Also present is the characteristic specificity of distribution after reinforcement although this animal showed no sign of any collateral behaviour. When these data samples originally ran with Program "TRIAD DIG" it was found that the most popular IRT triad, ending with a burst response, was the sequence 15.14.0. This initial estimation of 2nd order probabilities proved that the Sidman effect was further dependent upon whether or not the first response of the triad was reinforced. Table 13a and b describe these probabilities for bursting following all non-reinforced responses (N), categories 14 and 13, and all non-reinforced categories except 13 and 14 i.e. (n). It can be seen that a non-reinforced response was more likely to be followed by very short IRTs if it was preceded by a reinforced response. This data was calculated by programs "TRIAD", "MESCALINE" and "PROBE INFORMATIC 3 BY 6TH". The appropriate outputs are contained in the corresponding Computer Appendices. Figure 23 summarizes the finding in histogram form. Another analysis was carried out to determine if burst responding was affected by even longer serial dependencies. As a run of non-reinforced/

[SR. N.B = 119]	[SR.N = 512]	[SR. N.B/SR.N = SR.N |B = 119/512 = 0.2324]
[SR.14.B = 67]	[SR.14 = 281]	[SR.14.B/SR.14 = SR.14|B = 67/281 = 0.2384]
[SR.13.B = 26]	[SR.13 = 144]	[SR.13.B/SR.13 = SR.13|B = 26/144 = 0.1806]
[SR. n.B = 26]	[SR.n = 87]	[SR. n.B/SR.n = SR.n |B = 26/ 87 = 0.2989]

[N. N.B = 121]	[N.N = 933]	[N. N.B/N. N = N. N |B = 121/933 = 0.1297]
[N.14.B = 35]	[N.14 = 207]	[N.14.B/N. 14 = N. 14|B = 35/207 = 0.1691]
[N.13.B = 32]	[N.13 = 214]	[N.13.B/N. 13 = N. 13|B = 32/214 = 0.1495]
[N. n.B = 54]	[N.n = 512]	[N. n.B/N. n = N. n |B = 54/512 = 0.1055]

TABLE [13a]

2nd ORDER Conditional Probabilities for ($0 \leq IRT \leq 5$)
i.e. A Burst Response (B). Sample F9 (9days).

[SR. N.B = 133]	[SR.N = 375]	[SR. N.B/SR.N = SR.N |B = 133/375 = 0.3547]
[SR.14.B = 75]	[SR.14 = 173]	[SR.14.B/SR.14 = SR.14|B = 75/173 = 0.4335]
[SR.13.B = 32]	[SR.13 = 100]	[SR.13.B/SR.13 = SR.13|B = 32/100 = 0.3200]
[SR. n.B = 26]	[SR.n = 102]	[SR. n.B/SR.n = SR.n |B = 26/102 = 0.2549]
[N. N.B = 115]	[N.N = 769]	[N. N.B/N. N = N. N |B = 115/769 = 0.1495]
[N.14.B = 24]	[N.14 = 159]	[N.14.B/N. 14 = N. 14|B = 24/159 = 0.1509]
[N.13.B = 30]	[N.13 = 153]	[N.13.B/N. 13 = N. 13|B = 30/153 = 0.1961]
[N. n.B = 61]	[N.n = 457]	[N. n.B/N. n = N. n |B = 61/457 = 0.1335]

TABLE [13b]

2nd ORDER Conditional Probabilities for ($0 \leq IRT \leq 5$)
i.e. A Burst Response (B). Sample RINGO (8days).

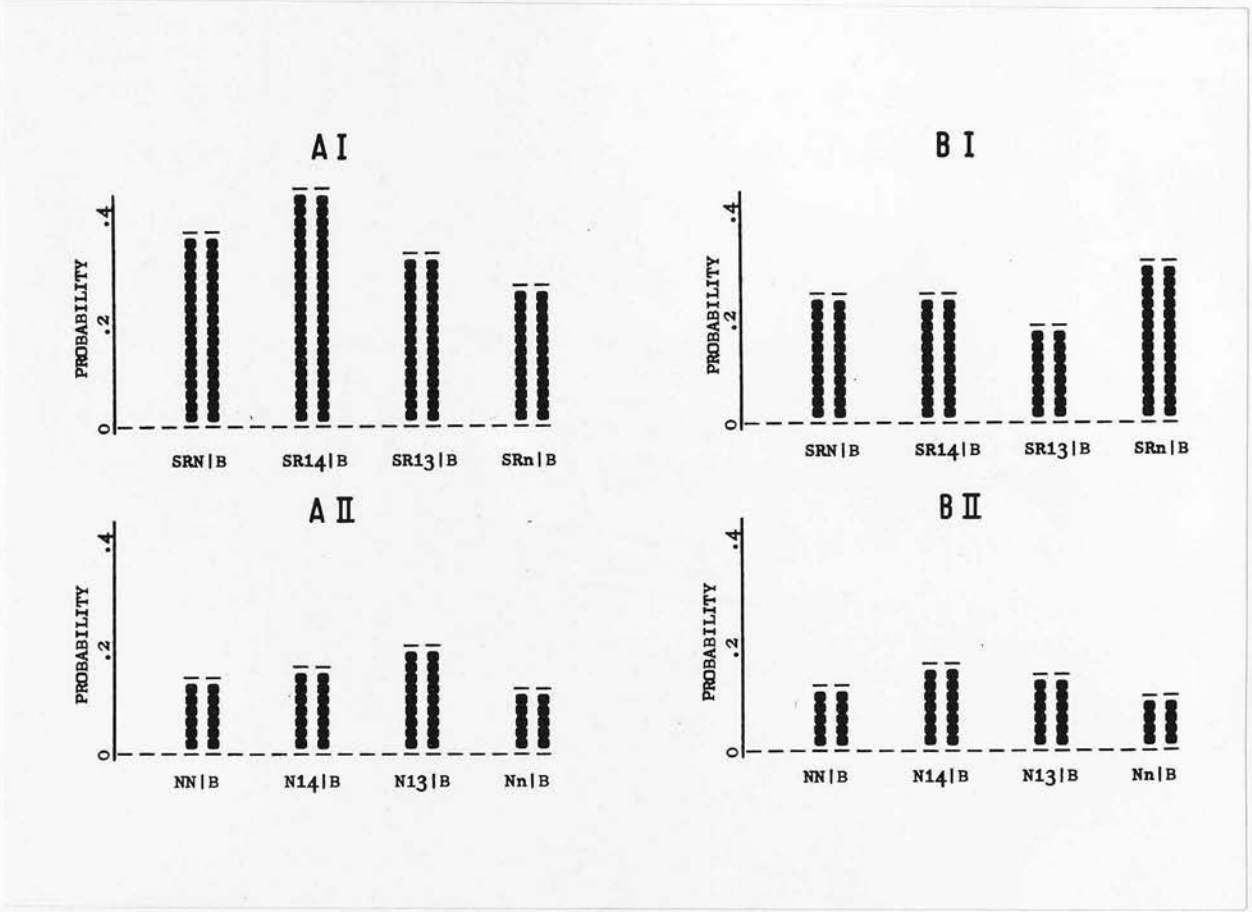


FIGURE [23]

2nd ORDER Conditional Probabilities for ($0 \leq IRT < 5$)
i.e. A Burst Response (B).

AI - Sample RINGO (8days) - 1st member of triad is SR
AII- Sample RINGO (8days) - 1st member of triad is N
BI - Sample F9 (9days) - 1st member of triad is SR
BII- Sample F9 (9days) - 1st member of triad is N

/non-reinforced responses progresses the probability of bursting seems to decrease. Furthermore the probability of bursting following a non-reinforced response tends to increase if the non-reinforced response was preceded by a run of more than on reinforcement (Figure 24). This information was obtained by means of programs "PROBE INFORMATIC 3 BY 6TH", "DISTANCE NAP" and "REINFORCEMENT NAP", and is contained in Table 14a and b. REINFORCEMENT NAP and DISTANCE NAP in this Table provide information similar to that shown above under LENGTH OF REINFORCEMENT RUN, DISTANCE FROM REINFORCEMENT and LENGTH OF NON-REINFORCED RUN, except that bursting is re-classified and ignored in previously identified positions. Also in the more specialized "NAP" programs these dependencies are computed up to 29th order sequences, although in Table 14 S^R- or N- runs longer than two are classified together.

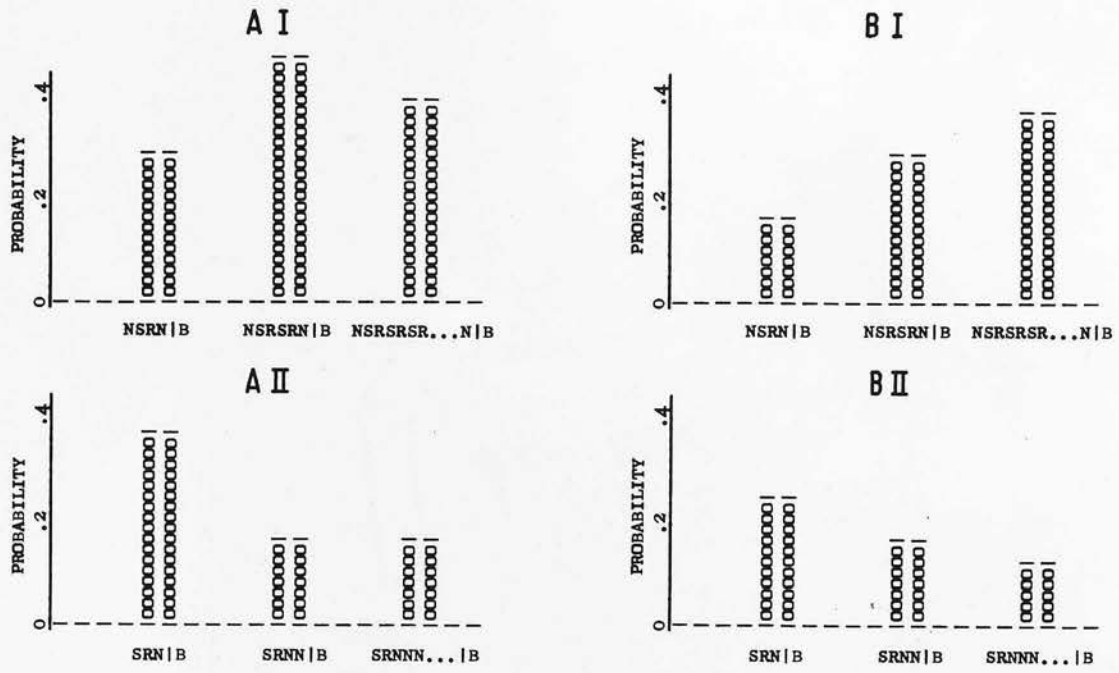


FIGURE [24]

The Conditional Probability of Burst Responding (B) as computed by programs REINFORCEMENT NAP and DISTANCE NAP.

AI - Sample RINGO (8days) - Following an SR-RUN
AII- Sample RINGO (8days) - Following an N-RUN
BI - Sample F9 (9days) - Following an SR-RUN
BII- Sample F9 (9days) - Following an N-RUN

LENGTH OF REINFORCEMENT RUN

$$N.SR.N|O = 0.1667$$

$$N.SR.SR.N|O = 0.2762$$

$$N.SR.SR.SR.N|O = 0.3429$$

$$SR.SR.SR.SR.N|O = 0.3571$$

DISTANCE FROM REINFORCEMENT

$$SR.N|O = 0.2324$$

$$SR.N.N|O = 0.1505$$

$$SR.N.N.N|O = 0.0828$$

$$SR.N.N.N.N|O = 0.0926$$

LENGTH OF NON-REINFORCED RUN

$$N|O = 0.1654$$

$$N.N|O = 0.1297$$

$$N.N.N|O = 0.1159$$

$$N.N.N.N|O = 0.1148$$

$$N.N.N.N.N|O = 0.1192$$

REINFORCEMENT NAP

$$N.SR.N|B = 0.1667$$

$$N.SR.SR.N|B = 0.2761$$

$$N.SR.SR.SR....N|B = 0.3535 \quad \text{SR RUN} > 2$$

DISTANCE NAP

$$SR.N|B = 0.2306$$

$$SR.N.N|B = 0.1625$$

$$SR.N.N.N....N|B = 0.1227 \quad \text{N RUN} > 2$$

TABLE [14a]

Conditional Probability of ($0 \leq IRT < 5$) as calculated by Program INFORMATIC 3 BY 6TH and the Conditional Probability of BURSTING as defined by the NAP Programs. Sample F9 (9days).

LENGTH OF REINFORCEMENT RUN

N.SR.N|O = 0.2680

N.SR.SR.N|O = 0.4471

N.SR.SR.SR.N|O = 0.4286

SR.SR.SR.SR.N|O = 0.3962

DISTANCE FROM REINFORCEMENT

SR.N|O = 0.3547

SR.N.N|O = 0.1570

SR.N.N.N|O = 0.1053

SR.N.N.N.N|O = 0.1429

LENGTH OF NON-REINFORCED RUN

N|O = 0.2159

N.N|O = 0.1495

N.N.N|O = 0.1355

N.N.N.N|O = 0.1364

N.N.N.N.N|O = 0.1092

REINFORCEMENT NAP

N.SR.N|B = 0.2893

N.SR.SR.N|B = 0.4528

N.SR.SR.SR....N|B = 0.3816 SR RUN >2

DISTANCE NAP

SR.N|B = 0.3526

SR.N.N |B = 0.1567

SR.N.N.N....N|B = 0.1653 N RUN >2

TABLE [14b]

Conditional Probability of ($0 \leq IRT < 5$) as calculated by Program INFORMATIC 3 BY 6TH and the Conditional Probability of BURSTING as defined by the NAP Programs. Sample RINGO (8days).

E X P E R I M E N T 13

These calculations were made in order to compare the properties of IRT distribution throughout the daily session on DRL15LH5.

METHOD

Sample F10 (25 days) was used and each daily session was divided into three approximately equal fractions. (Equal not in time but in number of IRTs). From the beginning of each session the three portions were labelled FRACTIONS 1, 2 and 3. Each fraction was identified and summed across the 25 days by Computer Program "FRACTIONS" contained in Computer Appendix 12. This program incorporated a version of program "HISTOSTAT RED" and printed out the 1st order IRT histograms for all three fractions.

RESULTS

Table 15 describes the overall 0 order distributions for fractions 1, 2 and 3. The most striking feature of this classification is the similarity of distribution for fractions 1 and 2, whereas 3 produces a more varied distribution. Also fraction 3 shows a marked increase in IRTs greater than 23 sec. The 1st order histograms can be seen in Figures 25, 26 and 27. The flattening of fraction 3 distribution is evident from Figure 27 which produces 9 distributions following IRTs which occupy more than 4% of the total output. Table 15 reveals that the probability of reinforcement is almost exactly the/

THREE FRACTIONS OF DAILY SESSIONS F10 DAYS 1-25

	FRACTION 1		FRACTION 2		FRACTION 3	
IRT	FREQ	PERCENT	FREQ	PERCENT	FREQ	PERCENT
0	75	3.0852	74	3.0553	50	2.1079
1	20	0.8227	36	1.4864	13	0.5481
2	2	0.0823	6	0.2477	5	0.2108
3	1	0.0411	4	0.1652	2	0.0843
4	0	0.0000	0	0.0000	3	0.1265
5	4	0.1645	1	0.0413	4	0.1686
6	4	0.1645	1	0.0413	1	0.0422
7	4	0.1645	2	0.0826	11	0.4637
8	7	0.2879	8	0.3303	18	0.7589
9	31	1.2752	18	0.7432	32	1.3491
10	69	2.8383	64	2.6424	67	2.8246
11	106	4.3603	111	4.5830	102	4.3002
12	187	7.6923	202	8.3402	187	7.8836
13	371	15.2612	336	13.8728	248	10.4553
14	528	21.7195	493	20.3551	356	15.0084
15	422	17.3591	443	18.2907	321	13.5329
16	214	8.8030	220	9.0834	219	9.2327
17	126	5.1831	136	5.6152	154	6.4924
18	72	2.9617	81	3.3443	117	4.9325
19	47	1.9334	30	1.2386	93	3.9207
20	29	1.1929	34	1.4038	58	2.4452
21	22	0.9050	18	0.7432	54	2.2766
22	17	0.6993	11	0.4542	44	1.8550
23+	73	3.0029	93	3.8398	213	8.9798

TABLE [15]

0 ORDER Frequencies and Percentages for the sum of the 3 IRT FRACTIONS taken from all sessions of sample F10 (25days).

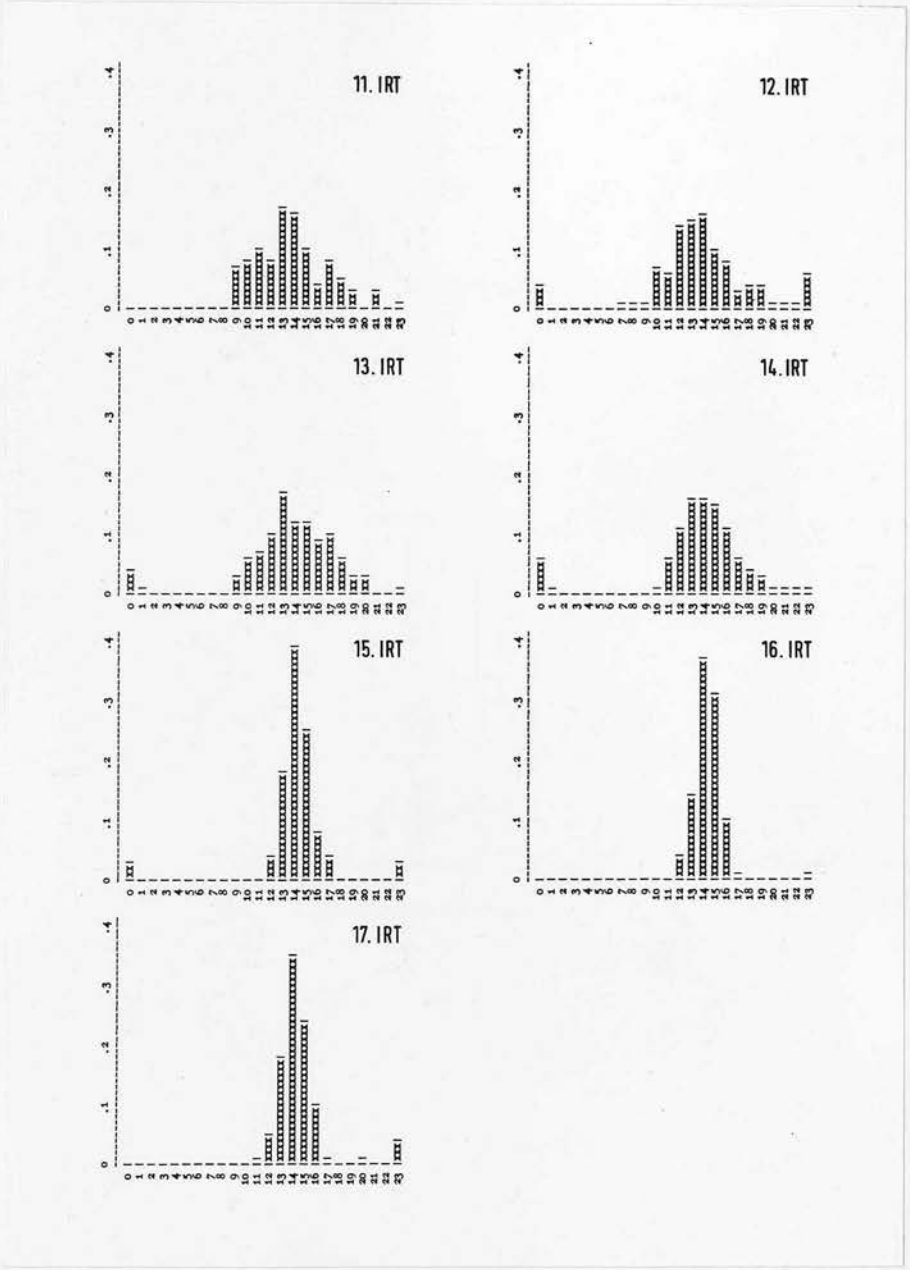


FIGURE [25]

1st ORDER IRT Distributions after classification into 1sec. band widths for the first third of each daily session in Sample F10 (25days) summed. i.e. FRACTION 1

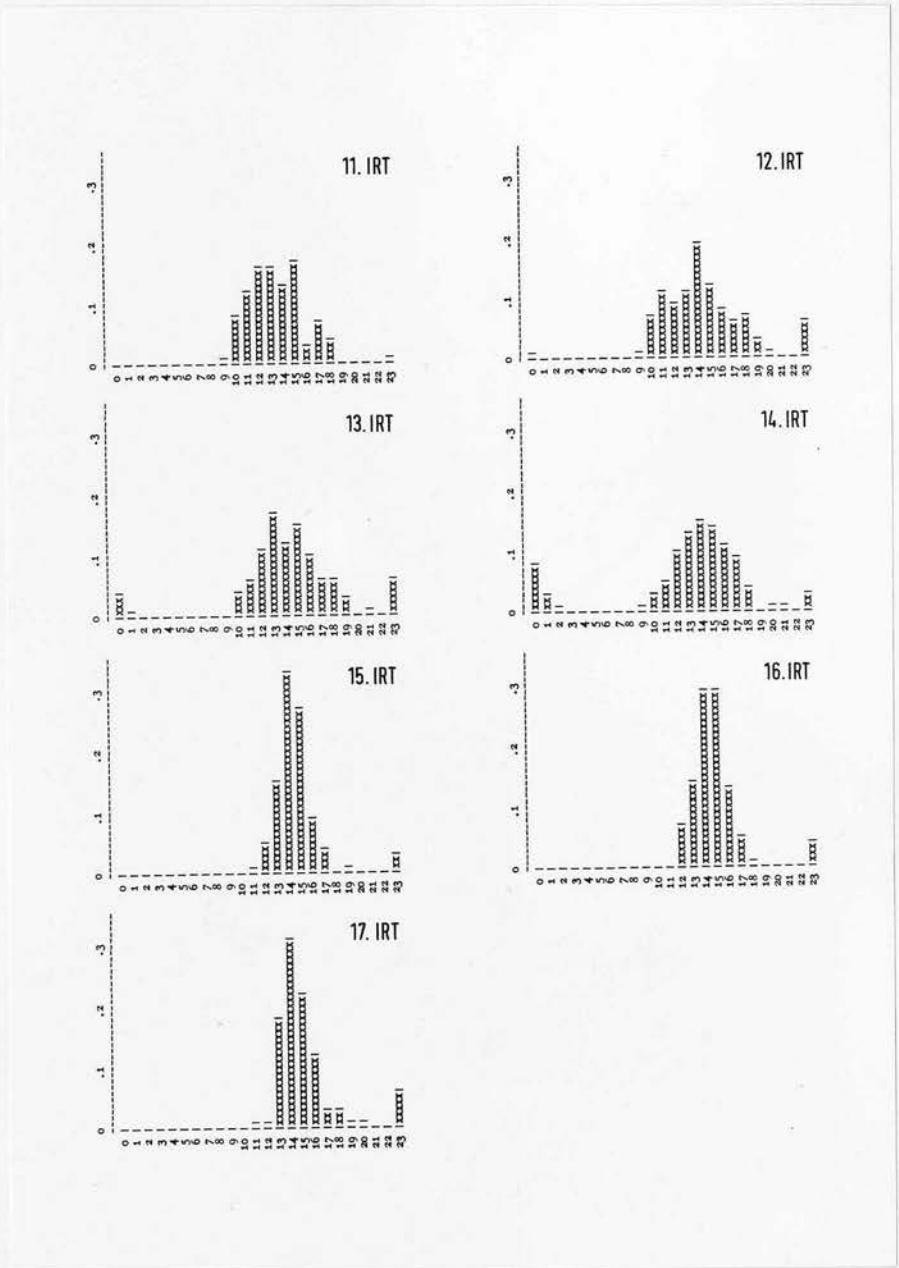


FIGURE [26]

1st ORDER IRT Distributions after classification into 1sec. band widths for the second third of each daily session in Sample F10 (25days) summed. i.e. FRACTION 2

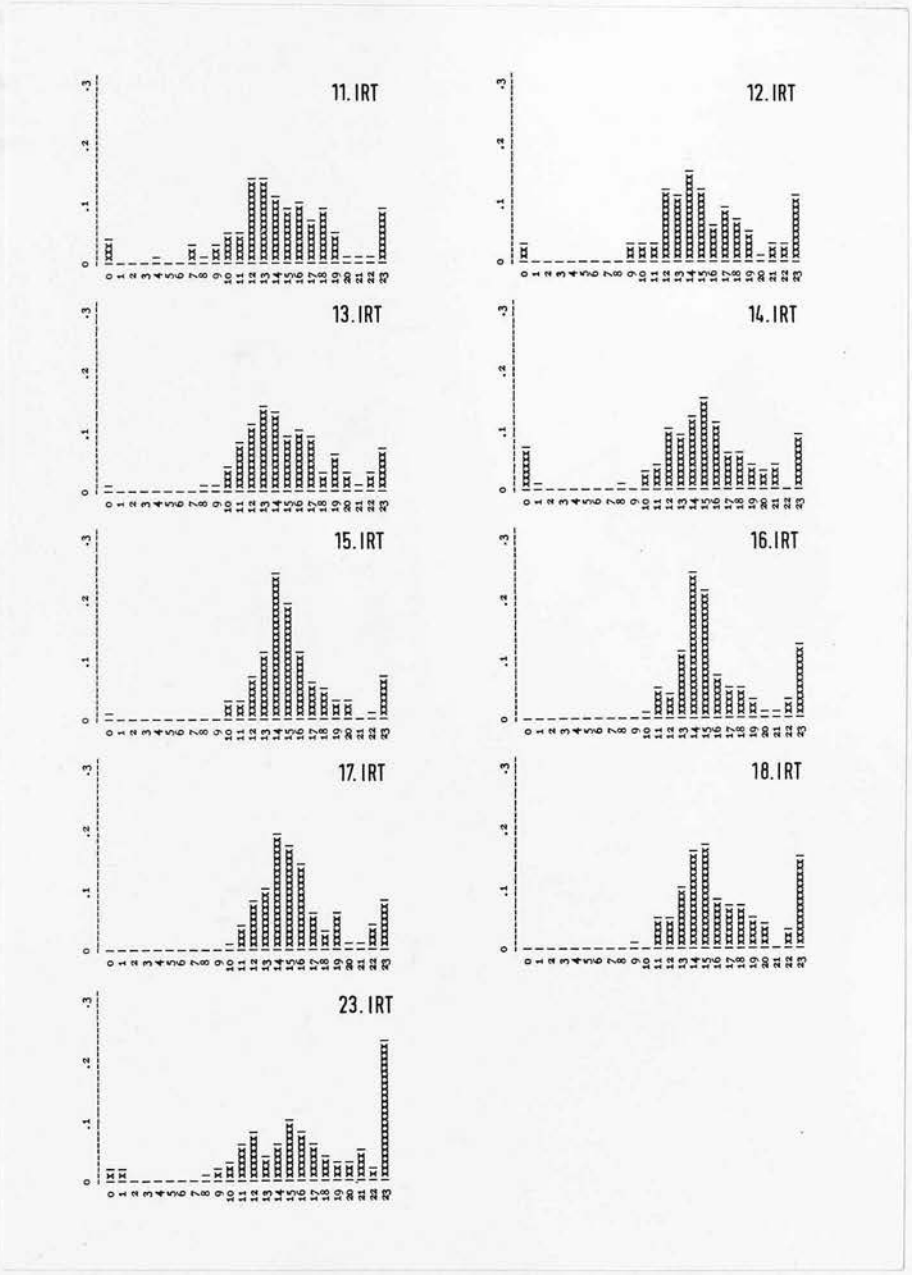


FIGURE [27]

1st ORDER IRT Distributions after classification into 1sec. band widths for the final third of each daily session in Sample F10 (25days) summed. i.e. FRACTION 3

/the same for all three fractions but the post-S^R distributions of Figure 27 (fraction 3) are not characteristic of the overall properties, showing no improvement in discrimination as in fractions 1 and 2.

EXPERIMENT 14

Ferster and Skinner (1957) defined a 'Conjunctive Schedule' as one in which two contingencies must be met and mentioned two combinations of DRL and FR which satisfy this definition. Firstly they described an FR drl schedule where an IRT satisfying the drl value was reinforced only when the FR was completed and secondly, pacing schedules, where a number of successive responses had to meet the drl specification. Kelleher, Fry and Cook (1959) exposed an animal trained on DRL20LH5 to the added contingency FR2 and refer to the resulting schedule as DRL20LH5FR2. Although they describe the ensuing change in IRT distribution in great detail they do not explain the new constitution of the schedule. It can only be hypothesized that Ferster and Skinner would call this particular schedule pacing (2) 20-25. The addition of this ratio requirement produced little change in baseline performance other than a decrease in rate and a more even distribution of reinforcement over each session. Revusky (1963) has published cumulative records showing a prolonged pause following reinforcement on VI Pacing, as was also demonstrated by Ferster and Skinner (1957, p.499). The present experiment was carried out to see if the addition of FR requirements to a DRL baseline would induce a change in the form of the post-S^R distribution./

/distribution.

METHOD

Two animals were used in the experiment, F9 on DRL15LH5 and MICK on DRL10. Each animal was trained for a minimum of 100 consecutive daily sessions and then subjected to an added FR contingency. This was continued for 28 daily sessions and then 6 consecutive sessions were sampled. Schedule for F9 was altered to DRL15LH5FR2 (i.e. pacing (2) 15-20 where the IRTs satisfying the ratio requirement are not necessarily successive), and for MICK, to DRL10FR3. Programs "MESCALINE" and "HISTOSTAT RED" were used in the data analysis and all sessions were terminated by an IRT $>$120 sec. In the case of animal F9, after the 6 day sample was taken on DRL15LH5FR2, a further five sessions were given on DRL15LH5FR3.

RESULTS

Cumulative records presented in Figure 28 show the development of a long post-reinforement pause on the DRL baseline of each animal after the FR addition. Comparison of the records for day 1 and day 29 during the DRLFR training indicates that reinforcement density is reduced per unit time or per unit response. Apart from the long IRTs after reinforcement, pausing is almost completely absent. Figure 29 gives the "HISTOSTAT RED" output for the total IRTs from F9 over the last 6 days on DRL15LH5. These 1st ORDER distributions are exactly as would be expected at stability/

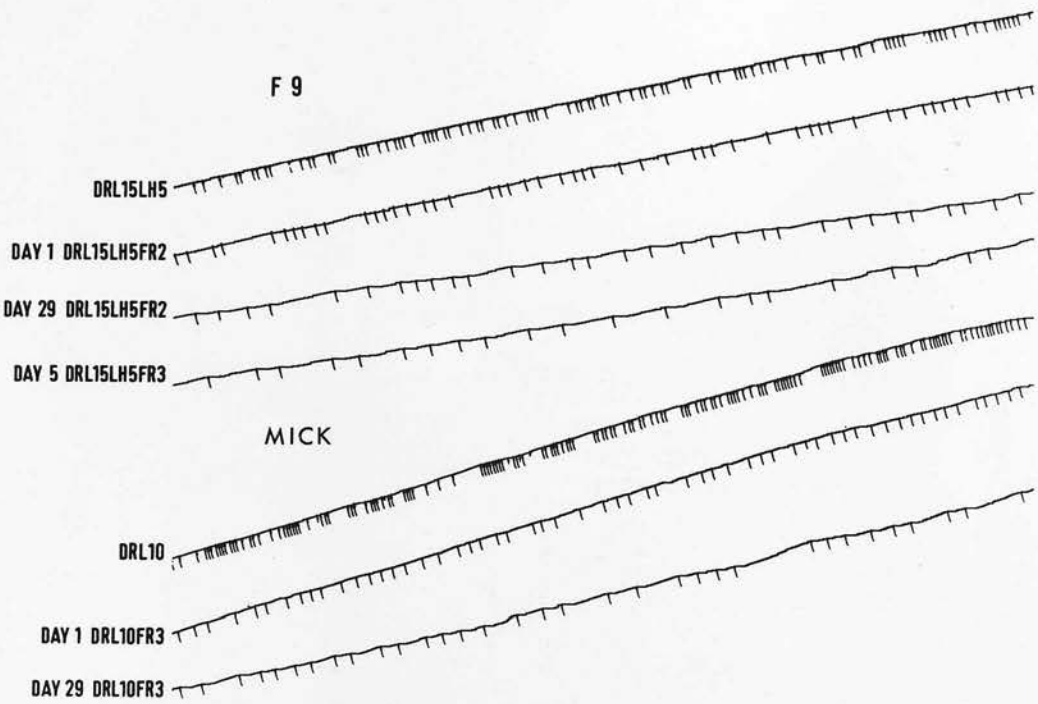


FIGURE [28]

Cumulative records showing the effects of conjunctive Fixed Ratio requirements upon DRL baselines.

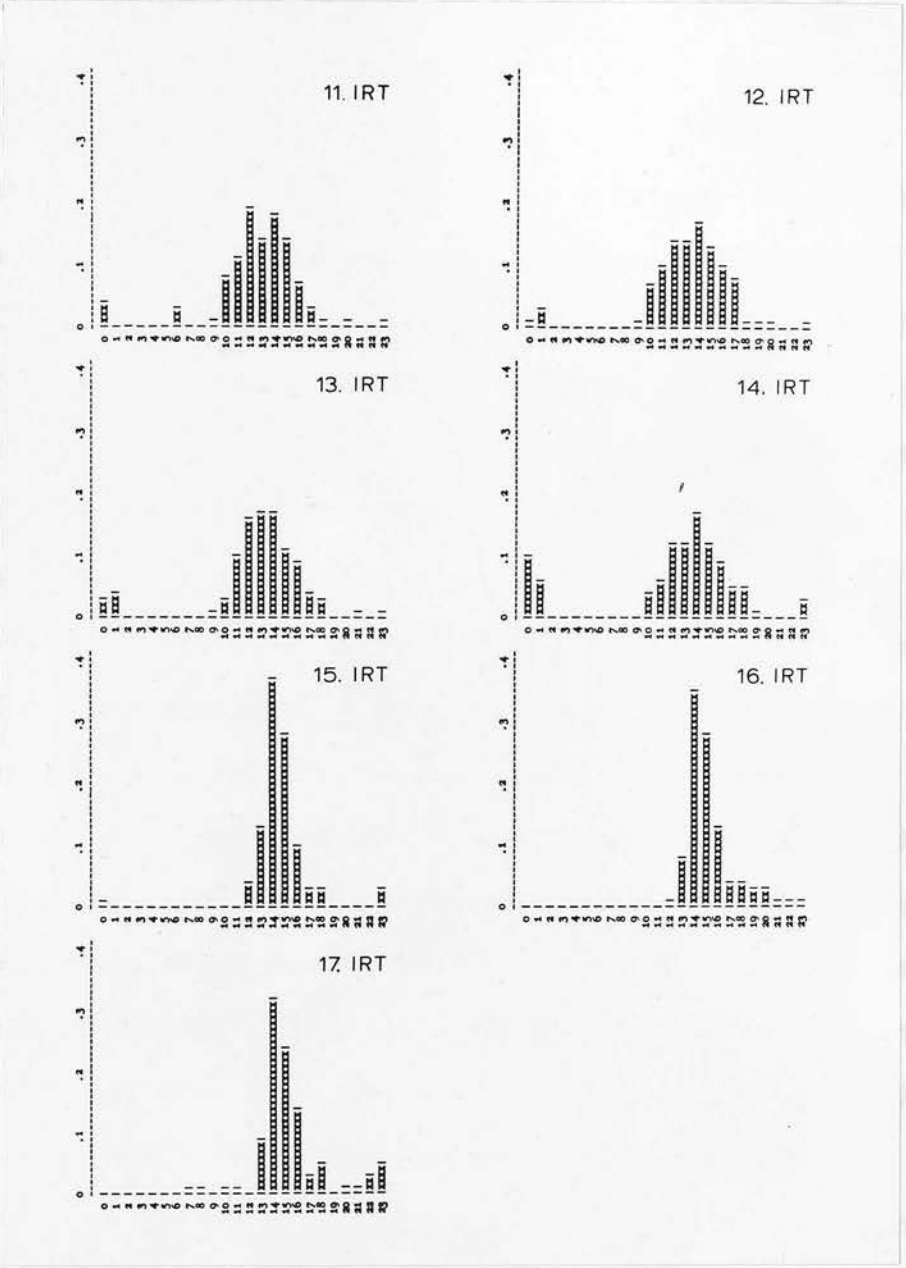


FIGURE [29]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample F9 (6days) before the addition of FR2. N = 1,688 IRTs.

/stability on this schedule and are similar to a previous sample from F9 i.e. F9 (9 days) in Figure 15. "HISTOSTAT RED" output for another 6 session sample following 28 consecutive days training on DRL15LH5FR2 is contained in Figure 30. The post-N distributions are much less precise when compared with performance before the addition of FR2. Post-S^R distributions take on a totally different form and around 50% of all IRTs within the limited hold period are followed by an IRT $\geq$23 sec. (i.e. the post-S^R pause) because only half of all $15 \leq$ IRTs < 20 are actually reinforced. For F9 the 0 order distribution is drastically flattened in the DRL15LH5FR2 sample and as many as 9 IRT bands occupy more than 4% of the total IRT output compared with 7 for the DRL15LH5 stability sample. Category 23 is enlarged due to the post-S^R pause but it is interesting to note that category 0 is not affected by the FR condition, even though the S^R density has been decreased. 0 order print-out from program "MESCALINE" can be inspected in Computer Appendix 2. Development of the post-S^R pause is also depicted in Figure 31 for rat MICK on DRL10FR3. This sample was only 5 sessions long because of print-out failure on day 34, however, the change in baseline performance is similar to that displayed by F9. In both Figures 30 and 31 the distribution after the post-S^R pause (i.e. 23.IRT) is the same as after any other non-reinforced/

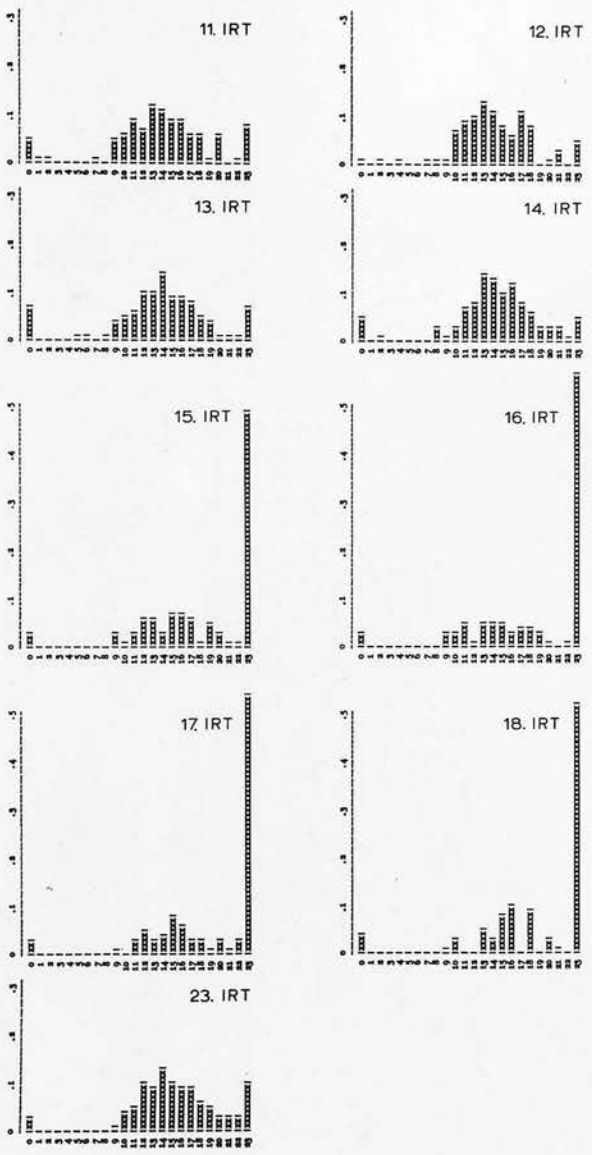


FIGURE [30]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample F9 (6days) taken from sessions 29 to 34 of training on DRL15LH5FR2. N = 2,233 IRTs.

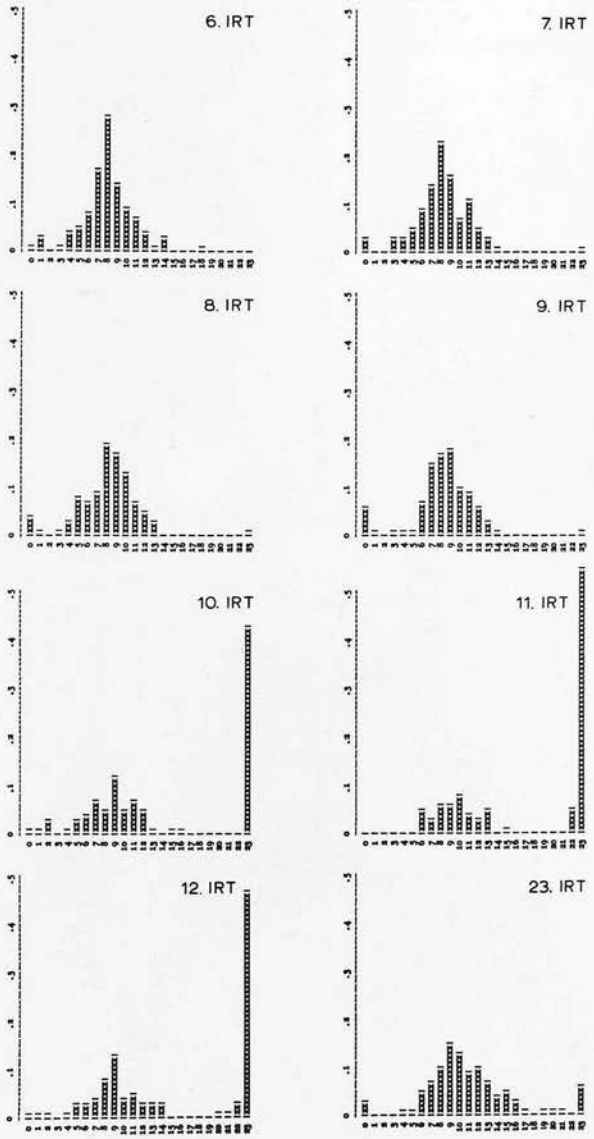


FIGURE [31]

1st ORDER IRT Distributions after classification into 1sec. band widths. Sample MICK (5days) taken from sessions 29 to 33 of training on DRL1OFR3.

/non-reinforced response. It can also be seen from the cumulative record in Figure 28 that F9 was able to tolerate the FR3 addition to the DRL15LH5 baseline. Further increases in the FR value would doubtless result in extinction.

CHAPTER 4

DISCUSSION AND CONCLUSIONS OF THE BEHAVIOURAL EXPERIMENTS

CHAPTER 4

4.1 A "steady state" experiment is carried out to obtain complete behavioural functions from single organisms acting as their own controls. This procedure avoids certain problems inherent in group-averaged functions and also supplies additional information.

During an experiment the question arises as to how long one should apply a particular value of the independent variable. In fact when each animal acts as its own control we must surely set a standard or stability criterion for this control behaviour in the steady state.

Cumming and Schoenfeld (1960) remark that the term stability refers to one or both of two things.

> "In some places, it means that behaviour is no longer changing significantly because it is close to its asymptotic value under the given conditions. In other contexts, the term seemingly refers to behaviour that is highly determined by the independent variable, and by implication to behaviour that shows minimal variability because it is not subject to random fluctuations based on other (fluctuating or transitional) variables."

The experimenter must ask himself some serious questions regarding his research design and the interpretation of his data.

> "When could the experiment have been stopped with any desired probability that no further change in the dependent variable would/

> /would have been observed? What is the actual variability in the behaviour under study? What is a satisfactory rationale for defining "stability" and what is a reasonable criterion to set for accepting behaviour as stable?"
>
> Cumming and Schoenfeld (1960).

The steady-state studies of Schoenfeld, Cumming and Hearst (1956) and Schoenfeld and Cumming (1957) used a stability criterion to determine when any given experimental procedure could be terminated. The first 7 days of exposure were allowed for adjustment to the new schedule; thereafter, the next six days and each succeeding group of 6 days were tested for stability. A six day period was considered to have met the stability criterion if the difference between the mean rate for the first 3 days and the rate for the second 3 days was no greater than 5% of the overall 6 day mean. If the difference between the sub-means was greater than 5% of the overall mean, another experimental day was added and similar calculations made for that day and the preceding 5 days. This process was repeated until the criterion had been met. It was then possible to calculate a similar determination for the next value of the independent variable.

Cumming and Schoenfeld (1960) examined the behaviour resulting from the continued application of one value of/

/of an independent variable over a long period of time. Pigeons were put on a reinforcement schedule defined by $t^D + t = 30$ second, and $\overline{T} = 0.05$ for 197 to 223 daily sessions with each bird. The results demonstrated the cyclical nature of behavioural stability and an examination of the first 6-day mean meeting the criterion showed that these values which would have halted the collecting of data under the earlier procedure did not closely conform with the final overall mean. In most cases these first criterion means were more than one standard deviation away from the mean of the distribution of all 6 day means. The criterion was satisfied in only a random fashion by following groups of six days, so it would appear that there are difficulties involved in pre-defining a stability criterion. Without a complete understanding of the controlling variables in a given schedule, stability cannot be defined. Training must be continued for a maximum number of daily sessions taking into account both the limitations of the experimental situation and the life-span of the animal.

14 consecutive daily IS^RT distributions are shown in Table 7a, b and c, for rats F4, F9 and F10 on DRL15LH5. A graphic selection from these in Figure 8 verifies that IS^RT distributions change little from day to day and a variety of stability criteria could be invented to fit the data. However, even after 110 daily sessions rat/

/rat F10 does not attain the higher probability of successive reinforcement demonstrated by F4 and F9.

Sample F10 (25 days) is displayed as distributions for consecutive sessions in Table 6a, b and c. This information is presented as frequencies, probabilities and IRTs per OP. and the stability is again only estimable in terms of a preconceived standard. There is a noticeable fluctuation in the modal IRT but this is merely a function of the size of band width utilized in the analysis. A larger band width would give the impression of more constant probabilities as has been described in Experiment 5. Experiment 2 proved that there were IRT distribution changes and increases in reinforcement probability taking place after more than 110 consecutive daily sessions on DRL15LH5.

Any criterion employed in the estimation of stability is purely arbitrary and is largely neglected in operant work for this reason. The eye is reckoned to be mightier than the calculating machine and behavioural stability is an elusive phenomenon which is recognised when it appears. Even when a criterion is used, it is not usually accompanied by either a rationale for choosing that criterion or an estimate of its reliability. This attitude has much in common with current research in neurophysiology where a baseline may be produced by the firing pattern in a cell or group of cells.

/cells.

4.2 The deprivation manipulations of Experiment 3 established that doubling the normal deprivation period had no appreciable effect upon the $IS^{R}T$ baseline. It might be argued that this maintenance of stability was a result of the 23 weeks of consecutive DRL training, and that earlier in the experiment such manipulations may have produced more noticeable effects. This would be in agreement with other findings for the effects of drugs on operant baselines.

It can be seen in Figure 3 that in the case of rat E1, one of the two animals demonstrating an interference with baseline performance at 72 hrs. deprivation, there is a considerable increase in burst responding.

Conrad, Sidman and Herrnstein (1958) do not report this increase in small IRTs nor do they observe a breakdown in performance up to 70 hrs. deprivation. However, their baselines do not achieve high probabilities of reinforcement and thus any disruption may be undetectable.

A possible conclusion from this finding may be that daily fluctuations in the DRL15LH5 baseline late in training is not a function of deprivation.

4.3 The various 1st ORDER IRT distributions presented for all DRL15LH5 animals in these experiments support the finding of Farmer and Schoenfeld (1964b)that the relative/

/relative frequency of a sequence of two reinforced responses was greater than that of a sequence of a reinforced response following a non-reinforced response.

Various authors have preceded this finding by reporting that on DRL schedules reinforcements tend to occur in relatively long sequences. However, it would be just as informative, on inspection of the cumulative record, to announce that non-reinforced responses tend to occur in long sequences.

The results of Farmer and Schoenfeld (1964) are not very impressive and are taken from a very small sample, but the 1 sec. band width 1st order IRT distributions produced by "HISTOSTAT RED" cannot be refuted. The greater accuracy of IRT value after S^R may be due to the presence of exteroceptive cues accompanying the presentation and ingestion of reinforcement. These may be more likely to initiate some form of collateral or mediating behaviour. Three animals in the experiments described, E4, F9 and F10 produced a form of collateral licking and gnawing peculiar to the post-S^R pause. This does not afford a satisfactory explanation because other animals showed no such observable activity and still produced a characteristic post-S^R distribution.

In Farmer and Schoenfeld's experiment this type of post-S^R collateral was impossible, since the dipper was always inaccessible except during the S^R period. They/

/They suggest as an explanation:-

> "that after S^R-termination a situation prevails that is relatively unambiguous compared with that after response occurrence. After S^R termination, the next S^R is available not less than 24 sec. later, while after a response the two possibilities exist that S^R is either postponed 24 sec, or it occurs immediately."

Unfortunately this is not an explanation and the issue can only be resolved by training DRL animals with a variety of reinforcers and reinforcement mechanisms and examining the corresponding post-S^R distributions.

4.4 When this post-S^R precision of interresponse-time was further analysed using the two variations of program "S^R DISTANCE" it became apparent that further dependencies were relatively unimportant. The positions in runs of responses which produced unique distributions were the first reinforced IRT in a reinforcement run and the first non-reinforced IRT in a non-reinforcement run. That is to say there were two types of IRT probability distribution (1) when the previous IRT was reinforced, and (2) when the previous IRT was not reinforced.

4.5 Another investigation examined the serial properties of S^R probability. Program "INFORMATIC 3 BY 6TH" revealed some evidence for further sequential influences/

/influences in IRT production. Figure 12 for sample F10 (25 days) and Figure 21, sample F9 (9 days), demonstrate that S^R probability increases with an increase in the length of the prior run of reinforcements. As more consecutive IRTs are reinforced the probability of reinforcement increases. This relationship does not exist for the prior occurrence of non-reinforced response runs and the probability of S^R is constant at any position of an N-run.

4.6 Means and standard deviations of 1st order distributions were calculated for DRL15LH5 samples from four animals. 1st order SD's reflect the difference in post-S^R and post-N IRTs (Fig. 17) but this difference is completely undetectable on inspection of 1st order means (Figure 16). Contrary to the findings of Ferraro etal. (1965) it appears that the mean IRT lengthened as a function of the immediately preceding IRT from 1st IRTs 10 to 13. IRTs shortened as a function of the immediately preceding IRT from 14-19. However, this relationship between 1 sec. classification IRTs and the mean of the following IRT is almost linear. This is a similar finding to that of Snapper etal. (1966) for median IRTs on continuous reinforcement.

4.7/

4.7 The averaged uncertainty calculation of Experiment 10 failed to throw any light on the previously identified serial properties. There was no decrease in uncertainty supplied by considering longer trains of IRTs. Frick and Miller (1951) admit that such techniques do not provide any startling new insights into operant conditioning but they emphasise the possibilities of incorporating the qualitative aspects of the behaviour into a completely quantitative account. There is little doubt that measures of rate alone provide an enormous loss in information content. Even 0 order distributions do not give a complete description. An operant baseline is merely a simple process for the demonstration of information theory applications in the paper by Frick and Miller.

i.e. "This study has something of the flavour of using heavy artillery to shoot a rabbit".

To take another meaning from this statement perhaps heavy artillery would be rather inaccurate in shooting rabbits. The trouble with this measure is that rate is largely ignored and it is rate which reflects the serial properties of behaviour on lever-pressing baselines.

4.8 The IS^RT distributions described in Figure 8 confirm the previous findings of Farmer and Schoenfeld (1964a)and Ferraro etal. (1965). These differ considerably/

/considerably from the corresponding IRT distributions and their hyperbolic form resembles the exponential "random interval" distribution (Farmer, 1963). The modal IS^RT is around the DRL value i.e. between 10 and 20 sec. It can be shown that this particular probability is equal to the conditional probability of S^R following S^R. IS^RT distributions cannot be prepared from 0 order IRT distributions and vice versa. The sequential IRTs in sample F10 (25 days) were converted into IS^RTs and the 1st order distributions were computed by program "IS^RT ANALYSIS". All the 1st order distributions were similar in form so this finding lends support to the hypothesis that only the identity of the prior IRT is important. That is to say there are two forms of distribution, post-S^R and post-N. Contrary to the expectations of Farmer and Schoenfeld the sequential properties of IS^RTs are of no particular importance.

4.9 In Experiments 1 and 2 it has been shown that burst responding is almost completely extinguished after 23 weeks of DRL15LH5 training. This was predicted because bursting was never reinforced on this schedule. There was almost no auditory feedback from lever operation in the experiment and this could explain the initial presence of a high probability for small IRTs. Kelleher, Fry and Cook (1959) removed auditory feedback for the lever/

/lever response on DRL LH schedules and found no difference in timing behaviour but very slight increases in burst responding. This lack of distinctive response produced stimuli may be responsible for the development of a subsidiary peak at short IRTs. Further experimentation is required in order to elucidate this relationship.

Experiment 12 describes a detailed serial analysis of burst responding on a DRL15LH5 baseline for two animals. The much quoted report by Sidman (1956a) that bursts become more likely after non-reinforced responses nearer the lower bound of the reinforced interval, appears to be subject to longer serial influences. This 1st order probability is further dependent upon whether or not the previous IRT was reinforced. Also the probability of the combination NB increases with the lengthening of a prior S^R-run and decreases with the lengthening of an N-run. The Sidman effect may result from the fact that Ns nearer the lower bound of the LH period are more probable after S^R and bursting is more likely to follow the sequence S^RN. Therefore there is an increase in the probability $cp(S^RN|B)$ where N is approaching the lower bound of the reinforced IRT interval.

4.10 Ferraro etal. (1965) have suggested that very short IRTs seem to be a better initiator of the criterion response pause than longer but still unreinforced IRTs./

/IRTs. However, the 1st order distributions for O.IRT in Figures 13, 15, 20 and 22 where $0 \leq IRT < I$ occupied more than 4% of the total IRT output, show that this speculation is incorrect. There is no increase in the probability of a reinforcement after a burst response and the IRT distribution is similar to that following other non-reinforced IRTs < 15 sec.

IRTs greater than the upper bound of the LH period are uncommon as the distribution modes are almost all clustered around the 14th second.

4.11 The problem of collateral behaviour has been exhaustively reviewed in Chapter 2 of this thesis. It can be argued that any temporal discrimination is only possible as a result of discriminations along other continua. The internal cues of Anger or Sidman's internal clock seem to highlight an unresolved philosophical issue. Perhaps the overt incidence of collateral behaviour points to the real identity of the so-called temporal modality. Collateral behaviour is a chain of observable behavioural acts occurring in a consistent and predictable fashion. The adventitious reinforcement of this mediating activity produces a so-called temporal discrimination.

A human being can space his responding more accurately than can the rat and without any noticeable/

/noticeable stereotyped behaviour. He may be counting or reciting the national anthem or indulging in some unseen behavioural chain. Any of this activity could presumably be monitored by appropriate physiological recording; thus at stability on DRL some measure of CNS activity must surely satisfy the definition of collateral behaviour, even in the laboratory rat.

In two rats on DRL15LH5, E4 and F9, a reliable behavioural chain of dipper gnawing or licking appeared after each reinforcement. This was successfully blocked by application of an unpleasant tasting paste containing quinine. In Experiment 4, rat E4 showed a complete change in form of IRT distribution after S^R and the new distribution was similar to that generated after a non-reinforced response. Rat F9 in Experiment 11 reacted to the treatment by demonstrating a shift to the left in modal IRT for the post-S^R distribution. As the form of the post-S^R distribution was maintained, it was hypothesised that the collateral gnawing shown in Figure 19 was only part of a more complex behavioural chain.

Where observable collateral behaviour was recorded, its abolition produced changes in IRT distribution, but five other DRL15LH5 animals generated IRT distributions of a similar form without any indication of collateral activity./

/activity. Therefore it must be concluded that accurate timing behaviour may occur without any obvious collateral activity.

4.12 Wertheim (1965) has shown that the shape of an IRT distribution changes during the session on a lever-pressing avoidance task. In Experiment 13 this possibility was examined in DRL15LH5. It was shown that IRTs $\geq$ 23 sec. occurred mostly towards the end of a daily session. Also the last third of a session generated a slightly flattened form of overall IRT distribution in comparison with the first two-thirds which were exactly similar. Analysis of the 1st order distributions within these three fractions showed that the characteristic post-S^R distribution was lacking in precision for the final third. This finding may be explained by the fact that casual analysis of post-S^R gnawing showed that it was often absent near the end of a daily session. It is also noteworthy that there is very little evidence of a warm-up period on this DRL baseline.

4.13 When the FR contingency was added after DRL stability had been achieved, a post-reinforcement pause was observed. The post-S^R pause has been the subject of very few experiments in the past but may well be a function of dipper oriented behaviour during liquid reinforcement/

/reinforcement schedules. The unavailability of recording facilities during this experiment rendered impossible an analysis of post-S^R behaviour. However, in the case of F9 the entire post-S^R IRT was occupied by a form of gnawing behaviour similar to that recorded on the normal DRL baseline. When FR requirements were removed, normal DRL LH behaviour returned within three daily sessions. The post-S^R pause quickly disappeared when the opportunity for two consecutive reinforcements was re-established.

CHAPTER 5

THE PSYCHOTOMIMETICS

CHAPTER 5

The Psychotomimetics

5.1 There is an ever increasing interest, both scientific and popular, in the psychotomimetic drugs. This erstwhile legitimate obsession has primarily been directed towards lysergic acid diethylamide (LSD), the hallucinogenic tryptamines and mescaline. Most of these compounds are of botanical origin although many new synthetic chemicals have now been discovered.

The literature is replete with vivid descriptions of their psychotropic power. In man they are capable of inducing remarkable changes in both behaviour and perception without any concomitant clouding of consciousness. They are given the generic title "psychotomimetic" because the symptoms which they produce may be similar to those occurring in the development of the major psychoses. Another terminology is "hallucinogen" which describes a prominent perceptual alteration, common to both the drug state and the schizophreniform illness. As with all "good copy" the pertinant literature has been exhaustively reviewed from all aspects and by authors of varied appreciation. However, a continuous filtering of the undisciplinary mixture has failed to separate out a coherent biochemistry of either the hallucinogenic drugs or schizophrenia./

/schizophrenia.

The following history will be brief and hopefully more critical than is customary in such a psychiatric hinterland.

5.2 Hasish (an extract from the flowering parts of the female Indian Hemp plant) or Marihuana (its weaker counterpart from the leaves and tops) has the redoubtable distinction of being classified as a narcotic but if, as so many pharmacologists maintain, it is in fact an hallucinogen, then it is the oldest recorded member of that family. It was described in 3,000 BC by Shen Nung and though eventually displaced by opium in China it later became a part of Indian secular and religious life.

Mescaline and the hallucinogenic tryptamines have been popular with the native Indians of Mexico and the Basin of the Rio Grande since long before the Conquistadores. These preparations from cacti, tree bark, seeds and foliage, taken as infusions, chewed or snuffed, were probably an intimate part of religious ceremony in the earliest South American civilisations. They are described as early as 1560 by the Franciscan monk, Bernardino de Sahagun in his writings concerning the Spanish conquest of Mexico.

5.3 Now, tetrahydrocannabinol has been extracted from hasish. Mescaline and some derivatives of N,N-Dimethyl-tryptamine have been isolated as the active principles/

/principles of the various American Indian concoctions.

The first hallucinogen of man's own invention (that is to say not recognised and copied from nature) was LSD-25. This D-lysergic acid diethylamide was synthesised by Hofmann (1938) and in 1943 he accidentally discovered its psychotomimetic effects. He had modelled the molecule on nikethamide thinking it might be an analeptic but it turned out to be one of the most potent psychotogenic substances of all time. 2 ug/kg I.V. produce effects in man and a considerable number of substitutions in the ring and amide system have failed to produce a more potent drug. For example, as we will discuss later, 2-Bromine substitution brings about total inactivity in LSD. Thus, the subsequent efforts of Hofmann and the Sandoz drug house have diverted the hallucinogenic drugs from anthropology to pharmacology, and Sandoz as well as science generally have profited from the transition.

Hofmann has also analysed the seeds from the three active American Morning Glories (Ololiuqui) and they proved to contain ergot alkaloids i.e. D-lysergic acid amide and D-isolysergic acid amide. It has been confirmed that fungal contamination is not the source of this weak hallucinogenic material.

5.4 Jean Delay (1965) credits Moreau in 1845 as the first /

/first in the Western world to explore the hallucinogenic drugs in a paper entitled "Hashish and Mental Illness". Moreau conducted drug studies on normal and highly gifted subjects. He concluded that in using Hashish it was possible to reproduce the primary aspects of mental illness. The writings of Thudichum (1884) and Kraepelin (1892) suggest a biochemical basis for some kinds of chronic mental disease, but following the synthesis of mescaline by Spath (1919), numerous workers became interested in mescaline intoxication and its possible relationship to mental disorders. Beringer (1927) has summarized much of this early work but it was Stockings (1940) who set the scene for contemporary thought.

> "the various diseases commonly known as the psychoses are all variants of the same disease process; and that the causative agent is a toxic body, probably a toxic amine with chemical and pharmacological properties similar to those of mescaline, and having a selective action on the various higher centres of the brain. The particular centres attacked, and the nature and content of the resultant psychosis are determined by the psychophysical make-up of the individual patient and his past mental and environmental experience. Finally, that the correct method of approach to the problem of the understanding of the nature and treatment of the psychotic diseases lies in the spheres of biochemistry and pharmacology."

5.5 The first specific hypothesis was developed by/

/by Osmond, Harley-Mason and Smythies (1952). They suggested that a methylated derivative of mescaline could be formed due to a fault in the pathway from norepinephrine (NE) to epinephrine by N-methylation. O-methylation of NE would lead to the production in the body of 3,4-dimethoxy-phenylethanolamine which is sufficiently like mescaline to have itself the possibility of psychotomimetic properties. Similarly 3,4-dimethoxyphenethylamine could be formed from dopamine by the addition of two methyl groups on the ring. In the schizophrenic there could be an inborn error of epinephrine metabolism leading to the production of mescaline-like compounds. We can evaluate this hypothesis in the light of its ability to explain the then known facts about schizophrenia. The occurrence of a biochemical abnormality within the physiological stress mechanism would explain both the clinical relationship between schizophrenia and stress and also the chronic nature of the illness. This abnormal process might only become operative if the turnover of catecholamines reached a certain level in response to stress and then a vicious circle would result. That is to say, the abnormal metabolite would induce even greater stress, this would produce more metabolite, and so on. The first findings to have any bearing on the validity of the trans-methylation hypothesis was the discovery by Axelrod (1959) that the main metabolic pathway for the/

/the metabolism of catecholamines is by O-methylation. Kety (1961) has since reported that this particular research was adumbrated by the original psychiatric hypothesis and that this affords an example of how an idea about one problem (the biogenesis of schizophrenia) yields unexpected dividends in another field (the metabolism of catecholamines).

5.6 Pollin etal.(1961) fed quantities of L-methionine to chronic schizophrenics who were receiving iproniazid. This would have the effect of increasing any aberrant transmethylation process which might be involved in the illness. Iproniazid (a monoamine oxidase inhibitor) prevents the breakdown of cerebral amines and methionine forms a sulfonium compound with adenosine. Baldessarini and Kopin (1963) have shown that L-methionine loading causes marked increases in S-adenosylmethionine in rat brain. It is this compound that donates the sulphur-linked methyl group to appropriate acceptor molecules, and is probably involved in both O- and N- methylation of monoamines. Thus the increase in cerebral amines and the availability of methyl groups might encourage the formation of toxic methylation products. Four of the twelve patients involved showed an increase in severity of symptoms. A similar deterioration in the mental state of schizophrenics has been reported by Brune and Himwich (1963) using both methionine or betaine (another methyl/

/methyl donor) and isocarboxazid. Also using methionine and isocarboxazid, Park etal. (1965) found that out of seventeen schizophrenics two became more psychotic.

5.7 It is well established that serotonin (5-hydroxy-tryptamine, 5-HT) results from the 5-hydroxylation of tryptophan followed by enzymatic decarboxylation of the intermediate 5-hydroxy acid. However, neither the acid nor the amine are psychotogenic compounds. Pollen etal. (1961) first reported that schizophrenic patients on high loadings of L-tryptophan and L-methionine exhibited marked behavioural changes which disappeared upon withdrawal of the methionine. This would suggest that the increase in transmethylation is in some way interacting with the accelerated turnover of 5-HT in these patients. Brune and Himwich (1962) stated this more explicitly by the idea that tryptophan and methionine together might be envolved in a common mechanism whereby indoleethylamines derived from tryptophan and excess methyl donors from methionine facilitate the formation of methylated indoleethylamines which can act as endogenous psychotogens. More recently Berlet etal. (1964) have suggested that N,N-dimethyltryptamine may be the endogenous psychotogen associated with schizophrenia. This hypothesis is supported by the finding of Axelrod/

/Axelrod (1961) that there is an enzyme present in rabbit lung which catalyzes the N-methylation of serotonin, tryptamine and phenylethylamine derivatives.

5.8 For many years psychiatrists have been searching for some toxic factor in schizophrenic plasma or urine which would present a clue towards a biochemical hypothesis. A large number of test systems have been employed but little tangible evidence has been forthcoming. It is a difficult task to estimate a foreign substance without a good hypothesis pointing to its identity. Then in 1962 Friedhoff and Van Winkle reported the isolation of dimethoxyphenethylamine (DMPE) from schizophrenic urine and claimed that it did not occur in control samples. A variety of conflicting reports regarding the estimation of similar substances peculiar to schizophrenic urine have lately appeared in the literature. Friedhoff and Van Winkle claimed that tritiated dopamine given to schizophrenics is found as 3,4-dimethoxyphenylacetic acid in the urine, and in 1963 they presented evidence that this conversion could take place in vitro in the presence of liver obtained from schizophrenics. There is, however, no confirmatory evidence that it is actually DMPE which is present in schizophrenic urine but it is possible that some schizophrenics are excreting a substance not found in normal subjects. This appears as a pinkish spot/

/spot on the chromatogram but has not been positively identified as a methoxylated derivative of phenethylamine. DMPE itself, is completely devoid of any hallucinogenic activity. This work is still continuing in many laboratories.

5.9 A similar search for a biochemical etiology in schizophrenia has placed emphasis upon the possible presence in schizophrenic urine of hallucinogenic substances similar in structure to 5-HT. The earlier literature contains a report by Bumpus and Page (1955) that N,N-dimethylserotonin (BUFOTENINE) is a likely component of normal urine. Using other methods Fischer (1961, a,b) was unable to find bufotenin in urine from 15 non-psychotic patients, but found it in 25 out of 26 hallucinating schziophrenics. Brune (1963) reported confirmation of Fischer's observations. He found a "bufotenin-like" substance in 9 of 17 urine samples from five schizophrenic patients and none in urine from three mentally-deficient patients. However Gross and Franken (1964) found bufotenine in the urines from 50 normal subjects. A critical paper by Siegel (1965) has failed to confirm the presence of bufotenine in the urine of either schizophrenic or normal subjects. The problem has been revitalized by Tanimukai etal. (1967) who point to an extraction error in all previous experiments and demonstrate appreciable quantities of/

/of both bufotenine and N,N-dimethyltryptamine in schizophrenic urine.

5.10 Indirect evidence in support of the transmethylation hypothesis stems from the existence of the disease homocystinuria. This inborn defect in methionine metabolism causes high blood levels of methionine associated with homocysteine in the urine. There appears to be a high incidence of schizophrenia in families with homocystinuria but this is a finding which requires more study.

Also, Heath etal. (1966) have reported that D,L-methionine-d,l-sulfoximine (M.S.O.) (an antimetabolite to methionine and glutamic acid) caused a diminution in psychotic symptoms when given to chronic schizophrenics and induced psychotic symptoms when given to normal subjects. This finding was explained by the fact that the schizophrenic has a pathologically overactive methylating system which is inhibited by M.S.O. The psychotic symptoms in normal subjects could be due to inhibition of a normally behaving enzyme system.

5.11 McIsaac (1961) has put forward a theory based on the chemical similarity between the pineal skin-lightening hormone melatonin and the hallucinogens harmine and harmaline. Melatonin produced from serotonin in the/

/the pineal gland could be metabolised to 10-methoxyharmalan which was shown to produce changes in animal behaviour. Increased melanogenesis in schizophrenia has often been reported but this could merely be an artifact of phenothiazine medication. Greiner and Nicholson (1965) reviewed the necropsy material for the years before phenothiazines were in use and found that melanin concentrations were still considerable. The hypothesis is that in the schizophrenic there is a defect in the O-methylation of N-acetylserotonin resulting in some harmaline alkaloid instead of melatonin. Melatonin, being a "lightening-factor" influences the conversion of tyrosine to melanin and thus a fall in melatonin gives rise to increased melanogenesis. As copper is essential in the formation of melanin Greiner and Nicholson treated some schizophrenics with the copper-chelating agent penicillamide plus a low copper diet. As well as a reduction in pigmentation they found a noticeable improvement in mental condition.

5.12 Current trends in biological psychiatry suggest that the most rewarding biochemical findings in the investigation of schizophrenia have been gleaned by making comparisons between the chemical formulae of the psychotomimetic drugs and the cerebral neurohumours. It is then desirable to ascertain the features of the/

/the hallucinogenic molecules, which are necessary for its unique effect. This may be the first step in explaining its mode of action. Some information in this respect is available for LSD, a compound which has attracted interest mainly because of its remarkable potency. For example 2-brom-LSD has notable anti-5HT action but no hallucinogenic properties, thus disproving the theory that anti-5HT action is related to the psychotrophic effect. LSD is, of course, a large and complex molecule and more benefit might be gained by studying the simpler structures of mescaline and the N-alkylated tryptamines.

Ideally these studies of structure-activity relationship should be carried out on human subjects but ethical and medico-legal considerations discourage such an approach.

5.13 Slotta and Muller (1936) found that the acid derivative of mescaline was completely inactive in humans. They also made the unusual discovery that 2,3,4-Trimethoxyphenethylamine was inactive in normal subjects, but very potent in the schizophrenic. This would be an important finding if it could be verified. Peretz etal. (1955) found that α-methyl-mescaline (which is also tri-methoxy amphetamine) was about twice as active as mescaline in humans. Early animal studies/

/studies by Noteboom (1934) and De Jong (1945) investigated the production of experimental catatonia by β-phenethylamine derivatives; unfortunately very large drug doses had to be given in order to have any effect. De Jong, however, does show that the replacement of the 4-methoxy group by hydroxy in mescaline abolishes activity. Smythies and Levy (1960) confirmed this finding in the rat using the Winter and Flataker test. They also demonstrated that activity was decreased by removing the 5-methoxy group and increased by substituting a benzyloxy group in the 4-position. The effects of β-phenethylamine derivatives on shuttle-box avoidance behaviour in the rat have been studied by Smythies and Sykes (1964 and 1965). It was found that mescaline at 25 mg/kg produced a biphasic effect on reaction time manifested by CAR inhibition followed by excitation. Mescaline at 12.5 mg/kg caused only a decrease in reaction time. 3,4,5-Trimethoxyphenylalanine was completely inactive and 3,4-dimethoxyphenethylamine and N,N-dimethylmescaline produced only slight effects unrelated to the mescaline profile. The inactivity of 3,4-DMPE has been confirmed in man by Hollister and Friedhoff (1965).

5.14 Bufotenine, the 5-hydroxy derivatives of N,N-dimethyltryptamine, or alternatively the N,N-dimethyl derivatives of serotonin, is naturally occurring and/

/and was isolated from toad warts by Wieland etal. (1931). It has been found, together with N,N-dimethyltryptamine and the respective N-oxides, to be one of the indolic components of "cahoba" a psychotrophic snuff taken by South American Indians (Stromberg, 1954; Fish etal., 1955). Fabing and Hawkins (1956) gave bufotenine to human beings and report that it caused psychotic episodes of short duration. In contrast Turner and Merles (1959) report that bufotenine is inactive. The conflict is probably introduced by the presence of the hydrophilic-OH group in bufotenine. This will tend to decrease the lipid solubility of the compound and thus impair its ability to penetrate the blood-brain barrier. Thus the drug will have to be given in a high dose whereby peripheral effects may obscure its true properties. The effects of N,N-dimethyltryptamine and of N,N-diethyltryptamine on humans have been studied by Szara (1957) and Sai-Halasz etal. (1958). They found both compounds to be hallucinogenic and noted the rapid onset and short duration of the effects when compared with LSD or mescaline. Psilocin, the 4-hydroxy derivative of N,N-dimethyltryptamine is also a potent hallucinogen (Wolbach etal. 1962). Szara (1961) has claimed that the 6-hydroxylated product of these compounds is the active metabolite but though 6-hydroxylation is a major pathway/

/pathway in the rat this is not so in man. Rosenberg etal. (1963) have compared N,N-dimethyltryptamine (DMT) with its 6-hydroxylated derivative in man and found 6-hydroxy DMT to be inactive. However, the marked reduction of lipid solubility probably introduced by the 6-hydroxy group complicates this comparison.

CHAPTER 6

DRUG EXPERIMENTS

CHAPTER 6

EXPERIMENT 15

This experiment sought to determine the effects of chlorpromazine, amphetamine and mescaline on timing behaviour in the rat.

There is little doubt that the effects of a drug upon a scheduled baseline depend at least on the nature of that schedule (Ray and Bivens, 1966), the training conditions and the route of drug administration (Westermann, 1961). Psychopharmacology, using laboratory animals as subjects, has made little contribution to clinical science and the thousands of published papers which appear each year, afford only scanty and confusing information. The basis of this dilemma is the fact that behaviour is being used as a substitute pharmacological baseline. Unfortunately much of this behaviour is not subject to the strict experimental control demanded by a strip of rat fundus in a bioassay bath.

With few exceptions such research is supported by psychologists seeking the security of pharmaceutical science and often brilliant chemists with no knowledge of behavioural techniques. Human psychopharmacology is hardly an improvement on the animal scene and the problem can best be described as "too many drugs and too little information".

Chlorpromazine (CPZ), the panacea of the major psychoses,

/psychoses, has attracted much attention, mainly because of its ability to suppress emotional behaviour. In this area the behavioural techniques of avoidance conditioning and the conditioned emotional response might be thought to provide a suitable experimental model in the laboratory animal. Another more specific explanation of the effects of CPZ proposes a loss of stimulus control of behaviour (Dews and Morse, 1961). That is to say the control of behaviour by exteroceptive and interoceptive environmental stimuli may be disrupted, with the result that CPZ might interfere with positively reinforced behaviour as well as aversively controlled behaviour. Methods are available for providing a direct comparison between drug effects on both positive and negative baselines but unfortunately the role of CPZ is still unclear. Hecht (1963) reported that CPZ affected both the latency and the stimulus control of the avoidance response, without altering a food-reinforced response. However Waller and Waller (1964) found that CPZ induced similar effects on both positive and negative reinforcement baselines.

Johnston and Bradley (1967) have shown that CPZ at doses from 0.5 mg/kg (I.P.) upwards produces profound effects on a discriminated Sidman avoidance baseline. Firstly, this experiment will attempt to compare the effects of similar doses of CPZ on a DRL15LH5 baseline./

/baseline.

Amphetamine, the paradigm central stimulant drug, has aroused much experimental interest in the past. It induces an increase in response rate on the DRL baseline with a concurrent decrease in reinforcement frequency (Sidman, 1955). There is some evidence that this change in IRT distribution may be as a result of the increased speed at which response chains are run off (Jetter, Lindsley and Wohlwill, 1953; Segal, 1962; Mechner and Latranyi, 1963). Laties etal. (1965) have described the effects of amphetamine administration upon a particularly well differentiated collateral chain in a rat on DRL 22. They found that collateral behaviour was almost entirely abolished when 0.5 mg/kg amphetamine was given before a daily session. Secondly, this experiment will describe the effects of amphetamine on the DRL15LH5 baseline of animal F9. As has been described in Experiment 11 this animal indulged in a form of gnawing behaviour after each reinforcement.

Finally the effects of mescaline will be analysed on the same baseline. There has been little pharmacological investigation of the hallucinogens in positive reinforcement situations. However, a study by Appel and Freedman (1965) has suggested that these drugs may have an all or none effect, producing a single period of no responding on a FR schedule.

METHOD/

METHOD

The subjects were four experimentally naive albino rats, E1, E3, E4 and F9 trained to stability on DRL15LH5. These animals have been described in previous experiments. Training conditions and apparatus remained unchanged and all IRTs were printed out in sequence. An appropximate 22 hr. water deprivation regimen was maintained throughout and food was available ad libitum in the home cage. After each session a water bottle was available for 15 minutes. Chlorpromazine, d,l-amphetamine sulphate and mescaline hydrochloride were dissolved in isotonic saline and injected intraperitoneally (I.P.) in a volume of 0.5 ml. All drug days were preceded and followed by a control day when 0.5 ml. saline was given. Chlorpromazine was injected 30 minutes before a daily session, amphetamine 5 minutes before, and mescaline immediately before. Chlorpromazine was given to rats E1, E3 and E4 at doses of 0.5, 1.0 and 2.0 mg/kg. Each treatment was separated by 14 days of normal training.

F9 received 4 administrations of both 12.5 mg/kg mescaline and 2 mg/kg amphetamine. Treatments with these two drugs were alternated and separated by at least 7 days of normal training sessions.

For rats E1, E3 and E4 time-out occurred after 250 responses. The first 300 IRTs were sampled from a daily/

/daily session of 90 min. for rat F9 except during amphetamine sessions when all the IRTs produced were analysed in order to maximise the sample size.

RESULTS

The quantitative effects of all three doses of chlorpromazine are shown in Table 16. 0 order percentage distributions are presented for each drug treatment and the preceding saline control session. All IRTs longer than 25 secs. occurring in the first 45 mins. of the session were identified and the sum of (IRT-25) for IRT> 25 secs. was expressed in minutes (T) in order to demonstrate any period of inhibition. This disruption might not be obvious from the IRT distributions. Saline injections or up to 2 mg/kg chlorpromazine had no effect on the DRL15LH5 baseline.

A pilot study showed that 1 mg/kg amphetamine and 8.5 mg/kg mescaline were completely inactive. Saline injections were without effect, producing normal IRT distributions and T values of less than 2 minutes. Table 17 describes the total, post-S^R and post-N distributions for the sum of 4 sessions under 2 mg/kg d,l-amphetamine, 12.5 mg/kg mescaline and saline control injection. These 4 saline control records were taken from the day before the first two amphetamine and the first two mescaline treatments. The three 0 order probability distributions are presented in Figure 32. Both drug treatments had almost no effect/

RAT E1

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	T
SALINE	5	1	0	0	0	0	0	0	1	1	3	5	6	15	21	12	9	7	3	2	1	2	1	4	1.14MIN.
0.5mg/kg	1	1	0	0	0	0	0	0	0	1	4	5	12	15	18	14	7	6	6	3	2	1	0	3	0.35MIN.
SALINE	2	0	0	0	0	0	0	0	1	0	2	4	5	8	14	16	7	12	7	5	4	5	0	10	0.04MIN.
1.0mg/kg	5	1	0	0	0	0	0	0	0	0	2	2	6	12	15	11	15	8	8	5	0	0	2	6	0.17MIN.
SALINE	6	1	0	0	0	0	0	1	0	1	3	1	2	6	11	7	10	10	7	5	2	3	5	19	0.62MIN.
2.0mg/kg	3	0	0	0	0	0	0	1	1	2	2	4	8	12	14	11	8	3	5	3	2	3	2	13	0.76MIN.

RAT E3

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	T
SALINE	8	1	0	0	0	0	0	1	1	0	2	7	6	16	16	11	10	8	4	3	2	1	1	3	0.12MIN.
0.5mg/kg	4	0	0	0	0	0	0	0	0	1	3	2	7	13	17	11	14	10	6	2	2	1	0	5	0.29MIN.
SALINE	4	0	0	0	0	0	0	0	0	0	0	1	6	13	15	12	12	9	7	3	3	4	2	6	0.63MIN.
1.0mg/kg	6	1	1	1	0	1	1	0	0	1	2	2	4	13	12	11	9	9	7	3	6	2	2	9	0.45MIN.
SALINE	3	0	0	0	0	0	0	0	1	1	0	2	5	9	14	14	16	14	4	4	4	2	1	5	0.94MIN.
2.0mg/kg	2	1	0	0	0	0	0	0	0	1	2	4	8	16	18	11	11	12	4	4	2	2	1	2	0.47MIN.

RAT E4

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	T
SALINE	2	1	0	0	0	1	0	1	0	1	2	6	6	12	22	17	12	8	4	3	1	1	0	1	0.06MIN.
0.5mg/kg	2	0	0	0	0	0	0	0	0	1	1	4	7	14	17	16	14	4	4	6	2	1	1	4	0.46MIN.
SALINE	5	1	0	0	0	0	0	0	1	2	1	4	4	12	20	18	14	6	3	0	1	2	1	3	0.74MIN.
1.0mg/kg	3	0	0	0	0	0	0	0	0	1	1	2	5	9	18	15	14	8	3	5	2	3	3	10	0.38MIN.
SALINE	2	0	0	0	0	0	0	0	0	1	0	3	7	8	19	17	12	10	4	1	3	1	3	9	1.32MIN.
2.0mg/kg	2	0	0	0	0	0	0	0	0	0	1	4	5	11	19	22	14	6	2	4	1	2	1	5	0.02MIN.

TABLE [16]

Percentage IRT Distributions for 3 doses of Chlorpromazine and Saline Controls for rats E1, E3 and E4 on DRL15LH5. T is the sum of (IRT - 25) expressed in minutes, for all IRTs > 25sec. occurring during the first 45min. of a daily session.

	SALINE CONTROL						12.5mg/kg MESCALINE						2mg/kg AMPHETAMINE					
	TOTAL		POST SR		POST N		TOTAL		POST SR		POST N		TOTAL		POST SR		POST N	
T	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
0	43	3.58	1	0.22	42	5.61	32	2.67			32	4.37	80	4.31			80	5.43
1	17	1.42			17	2.27	10	0.83			10	1.36	7	0.38			7	0.47
2	2	0.17			2	0.27	1	0.08			1	0.14	5	0.27			5	0.34
3													1	0.05	1	0.26		
4																		
5																		
6													29	1.56			29	1.97
7													44	2.37	1	0.26	43	2.92
8	3	0.25	2	0.44	1	0.13	7	0.58	1	0.21	6	0.82	106	5.71	7	1.84	99	6.72
9	9	0.75	2	0.44	7	0.94	9	0.75	2	0.43	7	0.95	137	7.39	12	3.15	125	8.48
10	34	2.80	7	1.55	27	3.61	22	1.83	6	1.28	16	2.18	195	10.51	29	7.61	166	11.26
11	48	4.00	8	1.77	40	5.35	55	4.58	17	3.64	38	5.18	148	7.98	33	8.66	115	7.80
12	78	6.50	15	3.32	63	8.42	80	6.67	20	4.28	60	8.19	193	10.40	57	14.96	136	9.23
13	148	12.30	60	13.27	88	11.76	149	12.42	61	13.06	88	12.00	164	8.84	38	9.97	126	8.55
14	188	15.67	111	24.56	77	10.29	163	13.58	120	25.70	43	5.87	139	7.49	47	12.34	92	6.24
15	143	11.92	89	19.69	54	7.22	164	13.67	114	24.41	50	6.82	112	6.04	44	11.55	68	4.61
16	110	9.17	53	11.73	57	7.62	81	6.75	35	7.49	46	6.28	91	4.91	19	4.99	72	4.89
17	83	6.92	42	9.29	41	5.48	109	9.08	44	9.42	65	8.87	74	3.99	14	3.67	60	4.07
18	71	5.92	22	4.87	49	6.55	65	5.42	12	2.57	53	7.23	55	2.97	12	3.15	43	2.92
19	45	3.75	8	1.77	37	4.95	48	4.00	6	1.28	42	5.73	49	2.64	15	3.94	34	2.31
20	27	2.25	1	0.22	26	3.48	22	1.83	4	0.86	18	2.46	52	2.80	11	2.89	41	2.78
21	24	2.00	5	1.11	19	2.54	17	1.42	2	0.43	15	2.05	40	2.16	9	2.36	31	2.10
22	19	1.58	2	0.44	17	2.27	40	3.33	2	0.43	38	5.18	15	0.81	4	1.05	11	0.75
23+	108	9.00	24	5.31	84	11.23	126	10.50	21	4.50	105	14.32	119	6.42	28	7.35	91	6.17

TABLE [17]

O ORDER, POST-SR and POST-N IRT Distributions for the sum of all IRTs recorded from 4 sessions under 2mg/kg Amphetamine, 12.5mg/kg Mescaline and Saline Control. Rat F9.

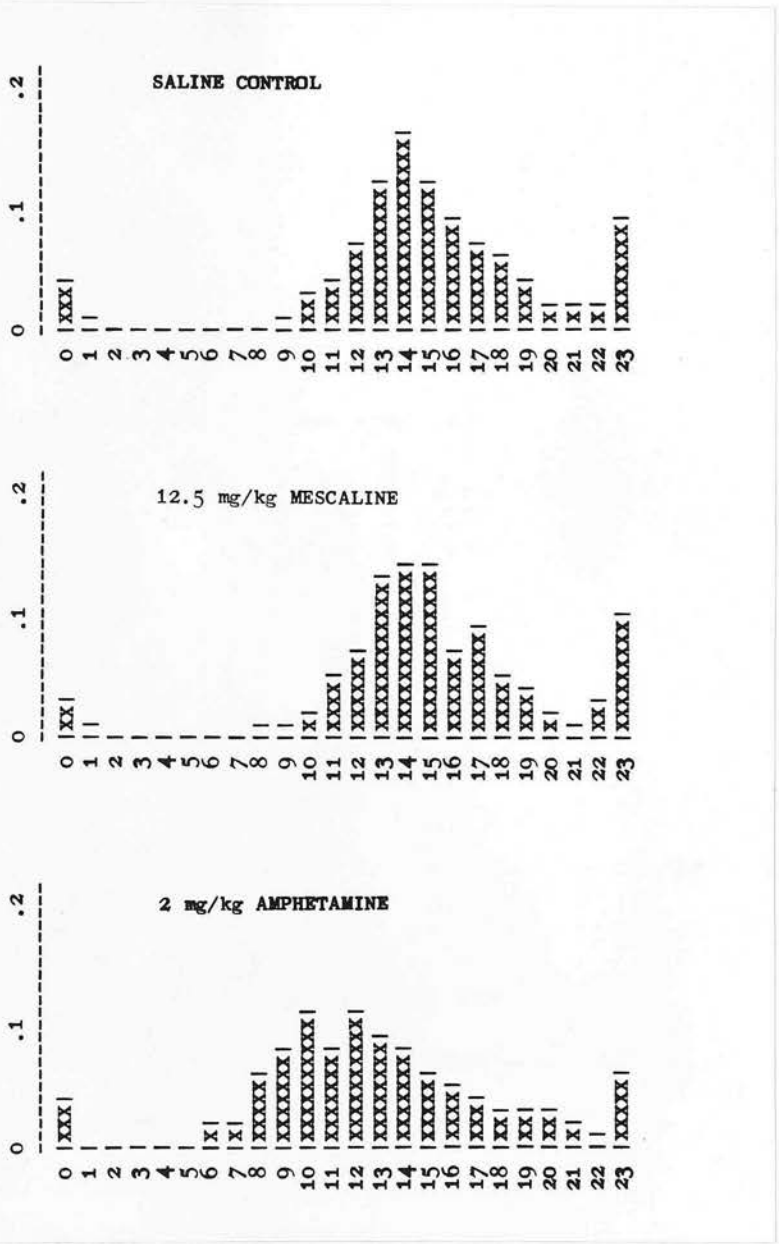


FIGURE [32]

O ORDER Probability Distributions taken from TABLE [17].

/effect upon the probability of bursting but 2 mg/kg amphetamine brings about a considerable reduction in IRTs $\geq$ 23. 12.5 mg/kg mescaline produced no apparent disruption of this 0 order distribution but from the cumulative records in Figure 33 it can be seen that there are several long IRTs occurring about 10 minutes after the drug injection. This period of inhibition lasted for about 20 minutes and was present during all four mescaline treatments, lasting for a similar time. When bar-pressing was re-started the distributions were normal. The 1st order distributions of Table 17 show that the mescaline effect is not apparent from either post-N or post-S^R distributions.

The 0 order amphetamine distribution graphed in Fig. 32 is flattened and skewed towards the shorter IRTs. There is a large increase in rate and a subsequent low probability of reinforcement. However, although the post-S^R distribution during amphetamine treatments is also shifted towards the shorter IRTs, it is still more accurate than after a non-reinforced response, i.e. $cp(S^R|S^R)$ is still larger than $cp(N|S^R)$. Auditory recording for collateral gnawing showed that it was almost totally absent during amphetamine sessions and was only transitory in form when actually measured.

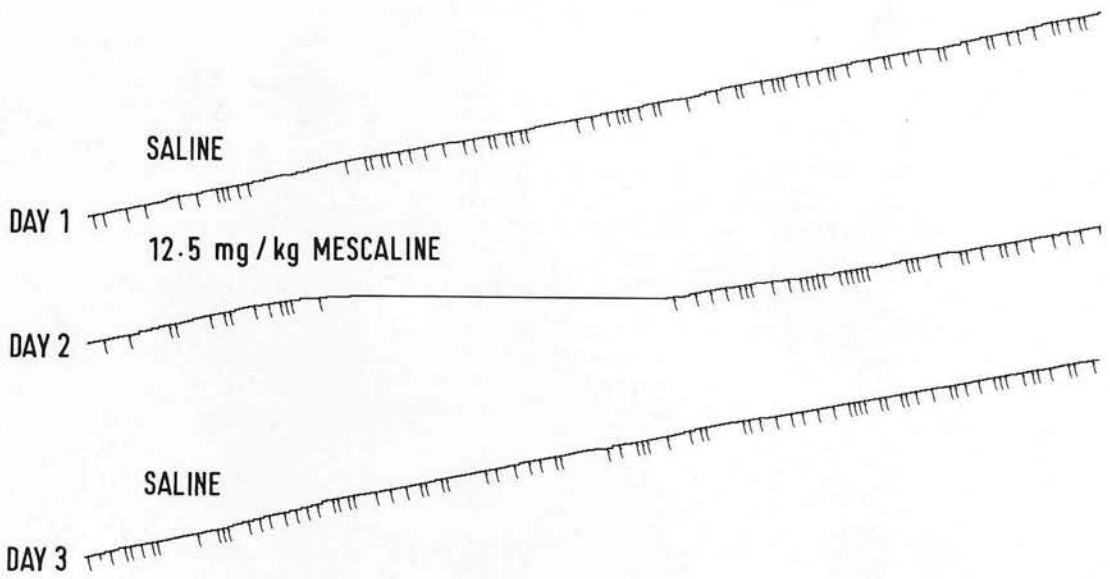


FIGURE [33]

Cumulative Records showing the effects of 12.5mg/kg Mescaline and Saline Control for rat F9 on DRL15LH5.

E X P E R I M E N T 16

Mescaline is phenylethylamine with methoxy groups at the 3, 4 and 5 positions. There are five possible locations for substituent groups on the benzene ring. These are in the 2, 3, 4, 5 and 6 positions. Positions 2, 3 and 4 may be referred to as otho, meta and para respectively and the two side chain carbon atoms may be labelled α and β (Figure 35).

The cause of the hallucinogenic effects produced by mescaline is not yet well understood. Block etal. (1952) suggested that a metabolite of mescaline may be the active agent but this issue is still unresolved. In vivo studies have shown that a large part of mescaline combines with liver protein (Block etal. 1952) and that the amine is excreted unchanged or as the oxidatively deaminated product 3, 4, 5-trimethoxyphenylacetic acid (Harley-Mason etal. 1958). Harley-Mason etal. also reported the presence of 3, 4-dihydroxy-5-methoxyphenylacetic acid and then Ratcliffe and Smith (1959) isolated 3,5-dimethoxy-4-hydroxy phenylethylamine from human urine.

Enzymes β-hydroxylating 3,4-dihydroxyphenylethylamine are known (Goldstein etal. 1965), and the β-hydroxyl group is an essential moiety in adrenaline and noradrenaline for their actions. Goldstein and Contrera (1962) have shown that mescaline is a weak substrate for dopamine-β-hydroxylase, and Musacchio and Goldstein (1967) have established/

/established that mescaline does not undergo β-hydroxylation in vivo.

Biogenic amines are known to undergo N-acetylation (Smith and Wortis, 1962) and Charalampous etal. (1966) have shown that mescaline is N-acetylated in man. Finally, Goldstein etal. (1961) have found that 3, 4, 5-trimethoxy-phenylethanol is a metabolite of mescaline in the rat.

The present experiment examines the effects of several derivatives of mescaline upon a DRL15LH5 baseline in the rat. The compounds tested were the acid, alcohol, N-methyl and β-hydroxy derivatives of mescaline (Figure 34) and also the ring-methoxylated derivatives of β-phenylethylamine.

There are 19 possible combinations of ring-methoxy groups in this symmetrical phenylethylamine moiety.

(A) Three mono-methoxy compounds; ortho, meta and para

(B) Six di-methoxy compounds 2,3 - 2,4 - 2,5 - 2,6 - 3,4 - 3,5 -

(C) Six tri-methoxy compounds 2,3,4 - 2,3,5 - 2,3,6 - 2,4,5 - 2,4,6 - 3,4,5 - (MESCALINE)

(D) Three tetra-methoxy compounds 2,3,4,5 - 2,3,5,6 - 2,3,4,6 -

(E) The penta-methoxy compound 2,3,4,5,6 -

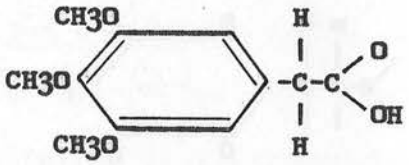
These 19 congeners were tested against the DRL15LH5 baseline in order to find out if any specific methoxy group configuration is essential to the behaviour/

/behaviour disrupting capacity of mescaline.

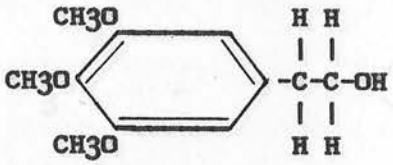
The ability of a compound to affect a conditioned response might be masked, or enhanced, by the ease with which that compound crosses the blood-brain barrier. Brodie and Hogben (1957) and Soloway etal. (1960) noted a direct correlation between brain penetration of substances and their lipid solubility as evidenced by their partition coefficient in a lipid solvent-water system. Accordingly the chloroform-water partition coefficients were determined for some of the compounds used in this study.

METHOD

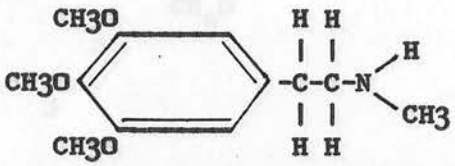
The rats used were F4, F9, ELVIS and RINGO as trained on DRL15LH5 for previous experiments. A daily session lasted for 90 minutes and was followed by 15 minutes access to a water bottle. The hydrochloride salts of all congeners of phenylethylamine were administered (I.P.) in doses of 12.5 mg/kg and 25 mg/kg. Drugs were dissolved in 0.5 ml. isotonic saline and the animal was placed in the experimental chamber immediately after the injection. A 0.5 ml. saline injection was given on the session prior to a drug day and at least 7 days normal training were left between each drug administration in order to ensure stability and to counteract any tolerance effects. The experiment was designed so that each drug treatment was replicated on two different animals. All IRTs were printed out in sequence during drug sessions and "T" was calculated/



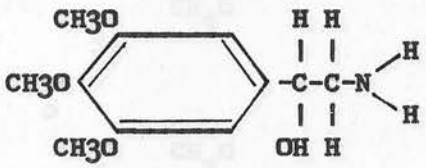
[1] ACID DERIVATIVE



[2] ALCOHOL DERIVATIVE



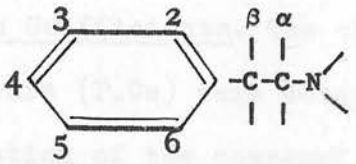
[3] N-methyl DERIVATIVE



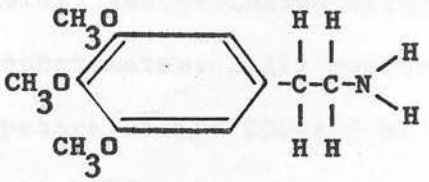
[4] β-OH DERIVATIVE

FIGURE [34]

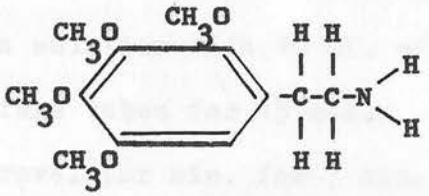
Structural formulae for four side-chain derivatives of Mescaline.



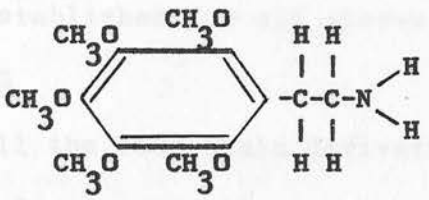
[1] **BASIC STRUCTURE**



[2] **3,4,5-Trimethoxy-β-phenylethylamine (MESCALINE)**



[3] **2,3,4,5-Tetramethoxy-β-phenylethylamine**



[4] **2,3,4,5,6-Pentamethoxy-β-phenylethylamine**

FIGURE [35]

The three active ring-methoxylated derivatives of β-phenylethylamine.

/calculated as described in Experiment 15.

Partition Coefficients. The chloroform-water partition coefficients (P.Cs) were determined in quadruplicate. The concentration of the compound in solution in sodium monohydrogen phosphate - sodium hydroxide buffer at pH 7.4 (0.1 Molar) was estimated using a Unicam 800 recording spectrophotometer. All spectra were recorded within the U.V. spectral range 200-450 mu and the unadulterated sodium phosphate buffer was used as a blank. Equilibration with chloroform was achieved by shaking a 10 ml. aliquot of the aqueous solution with 10 ml. of chloroform in glass-stoppered centrifuge tubes for 15 min. After centrifugation at 3,500 revs. per min. for 5 min. the aqueous phase was re-read against the extracted blank. Linear calibration curves were established for all chosen spectral peaks.

RESULTS

All the side chain derivatives of mescaline shown in Figure 34 were inactive up to 25 mg/kg. Of the 18 ring-methoxylated congeners of mescaline only two were active; 2,3,4,5 - tetramethoxyphenylethylamine and 2,3,4,5,6-penta-methoxyphenylethylamine (Figure 35). As the latter two compounds proved to be very potent at 12.5 mg/kg a second dosage of 6.25 mg/kg was tried instead of 25 mg/kg. Inspection of the "T" data in Table 18 shows that the most potent compound was 2,3,4,5,6- penta- followed by 2,3,4,5-tetra and then mescaline. Even the two other tetra-/

		ACID	ALCOHOL	N-METHYL	β-HYDROXY
25mg/kg	[1]	0.54	1.24	0.89	0.38
	[2]	0.22	0.00	0.71	0.41

		2-	3-	4-
12.5mg/kg	[1]	0.00	0.56	0.03
	[2]	0.06	0.94	0.00
25mg/kg	[1]	0.31	0.00	0.10
	[2]	0.00	0.12	0.75

		2,3-	2,4-	2,5-	2,6-	3,4-	3,5-
12.5mg/kg	[1]	0.00	0.00	1.13	0.29	0.00	0.76
	[2]	0.00	0.19	0.05	0.51	0.09	1.63
25mg/kg	[1]	0.00	0.41	0.39	0.37	0.00	0.00
	[2]	0.28	0.22	0.62	0.26	0.46	0.82

		2,3,4-	2,3,5-	2,3,6-	2,4,5-	2,4,6-	3,4,5-
12.5mg/kg	[1]	0.18	0.00	1.67	0.00	0.01	10.27*
	[2]	0.44	0.62	0.23	0.85	0.02	25.36*
25mg/kg	[1]	0.89	0.00	0.00	1.17	0.00	40.15*
	[2]	0.77	0.53	0.91	0.08	0.69	38.76*

		2,3,4,6-	2,3,5,6-	2,3,4,5-
12.5mg/kg	[1]	0.96	0.00	36.83*
	[2]	0.36	0.29	42.11*
25mg/kg	[1]	0.27	0.54	
	[2]	0.00	0.58	
6.25mg/kg	[1]			7.23*
	[2]			21.66*

		2,3,4,5,6-
12.5mg/kg	[1]	38.01*
	[2]	41.64*
6.25mg/kg	[1]	37.52*
	[2]	43.90*

TABLE [18]

The effects of Mescaline and 22 close congeners on a DRL15LH5 baseline. T values expressed in minutes are given for 2 treatments at each dose level on 2 different rats. Abnormal values, produced by the 3 active drugs are denoted by *.

/tetra- compounds and 5 tri- compounds were completely without effect at 25 mg/kg.

Table 19 gives the partition coefficients for the three active compounds plus the inactive 2,4,5- and 2,3,4,6-. It can be seen that P.C. increases as the number of ring-methoxy groups is increased. Thus it could be hypothesized that penta- would enter brain more readily than tetra- and tetra- would enter more readily than mescaline. This would explain the rise in potency which has been described on the lever-pressing baseline. However, 2,3,4,6- which is behaviourally inactive, has a larger P.C. than mescaline and 2,4,5- with a P.C. slightly less than mescaline is also inactive. So these results cannot simply be explained in terms of lipid-solubilities - but if it is assumed that the 3,4,5- configuration (which the three active compounds have in common) is necessary for the behaviour-disrupting action, then lipid solubility could explain the increased potency as a result of additional methoxylation.

These results have been confirmed on two avoidance baselines (Smythies etal. 1967) and this publication is contained in Appendix 1.

	2,4,5-	3,4,5-	2,3,4,6-	2,3,4,5-	2,3,4,5,6-
[1]	.5470	.6315	1.0339	1.5714	4.7388
[2]	.5809	.6762	1.1754	1.6169	5.2300
[3]	.7749	.7684	1.0900	1.8276	4.4525
[4]	.5507	.6781	1.2334	1.5831	4.9661
MEAN	.6134	.6886	1.1332	1.6498	4.8469
PEAK	289mμ	268mμ	281mμ	281mμ	278mμ

TABLE[19]

Chloroform-Water Partition Coefficients for
5 ring-methoxylated derivatives of β-phenylethylamine.

E X P E R I M E N T 17

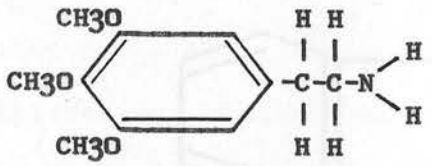
A comprehensive knowledge of structure-activity relationships in the psychotomimetic compounds should throw some light on their mode of action. To this end, it is important that the measured behavioural correlates of drug action in the experimental animal should reflect the unique psychotropic effect of a drug as well as its relative potency. Little reliable information is available concerning the behavioural effects of hallucinogenic or psychotomimetic agents in animals.

The present study is part of an investigation of the behavioural effects of ring and side-chain substitution in two recognised hallucinogens, mescaline and N,N-dimethyltryptamine. The compounds studied were 3,4-dihydroxyphenethylamine (DOPAMINE), 3,4-dihydroxy-5-methoxyphenethylamine[1], 3,5-dimethoxy-4-hydroxyphenethylamine[1], 3,4,5-trimethoxyphenethlamine (MESCALINE), N,N;dimethyltryptamine, 5-methoxy-N,N-dimethyltryptamine[1], and 5-methoxy-N-methyltryptamine[1]. These molecules are shown in Figures 36 and 37.

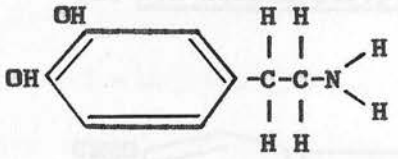
METHOD

Twelve experimentally naive male hooded rats were used. The animals were approximately 100 days old at the beginning of the experiment and were allowed food an water ad libitum. Experiments were run in a modified Levine Shuttle-Box;/

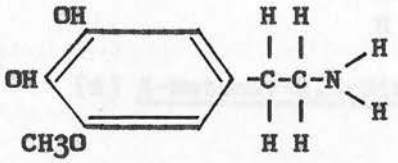
[1]Synthesized for the Psychopharmacology Research Branch by the Regis Chemical Company, Chicago, Illinois, under Contract No: SA-43-ph-3021



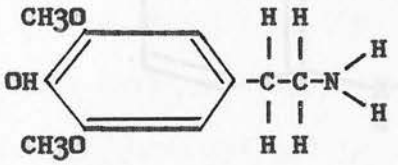
[1] 3,4,5-Trimethoxy-β-phenylethylamine (MESCALINE)



[2] 3,4-Dihydroxy-β-phenylethylamine (DOPAMINE)



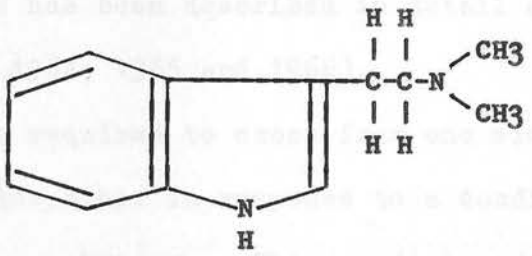
[3] 3,4-Dihydroxy-5-methoxy-β-phenylethylamine



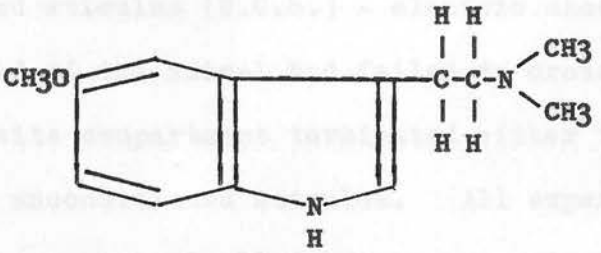
[4] 3,5-Dimethoxy-4-hydroxy-β-phenylethylamine

FIGURE [36]

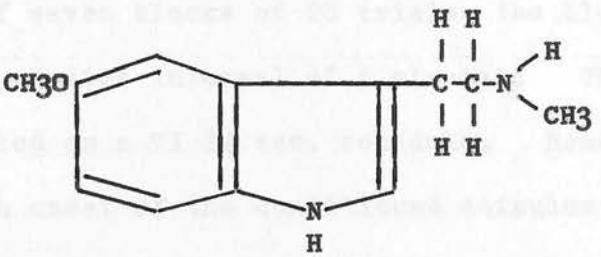
Three ring-hydroxylated derivatives of Mescaline.



[1] N,N-Dimethyltryptamine



[2] 5-Methoxy-N,N-Dimethyltryptamine



[3] 5-Methoxy-N-methyltryptamine

FIGURE [37]

Three N-Alkylated derivatives of Tryptamine.

/Box; this has been described in detail elsewhere. (Smythies etal. 1964, 1965 and 1966).

The rat was required to cross from one side of the shuttle-box to the other in response to a conditioned stimulus (C.S.) - a buzzer. This conditioned stimulus sounded for five seconds, at the end of which time the unconditioned stimulus (U.C.S.) - electric shock of 1.0 ma - was presented if the animal had failed to cross. A cross to the opposite compartment terminated either the conditioned stimulus or unconditioned stimulus. All experimental contingencies were controlled by a programming unit placed in an adjacent room. An experimental session of two hours consisted of seven blocks of 20 trials, the blocks being separated by a time interval of 5 minutes. The 20 trials were presented on a VI 24 sec. schedule. Reaction-time (RT) to each onset of the conditioned stimulus was automatically recorded and printed out correct to 0.1 secs.: i.e. the interval between the onset of the C.S. and the point where the rat crosses to the opposite compartment, thus terminating the C.S. or U.C.S.

Each animal was run seven days per week. After training to a criterion of at least 85% avoidance, injections of either drug or saline were given after 40 trials warm-up: i.e. 2 blocks of 20 trials allowing the animals to become accustomed to the experimental situation. The injected animal was then replaced in the/

/the shuttle-box and five minutes later the usual seven blocks of twenty trials began. Drugs[2] or control injections of 0.5 ml. isotonic saline were administered intraperitoneally and each drug day was preceded and followed by saline control days.

An animal served as its own control and results for each block of 20 trials are expressed in D-$\bar{S}$ scores i.e. the difference between the drug score and the mean of the pre-drug and post-drug saline scores.

Four animals received each dose level of a given drug according to a random design, and a fortnight was allowed between drug treatments in order to counteract any tolerance effects.

RESULTS

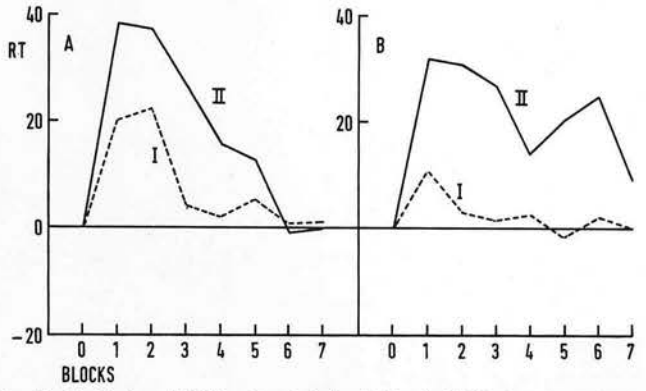
Using a technique similar to the one described in this experiment, previous investigations (Smythies etal. 1964, 1965 and 1966) have shown that hallucinogenic compounds have a biophasic effect on reaction time. Large doses cause an initial inhibition of the conditioned avoidance response (C.A.R.) above control values, which is reflected by an increase in reaction-time. This inhibition is eventually superseded by a decrease in reaction time below control values. During control saline injection sessions the trained rat will make an avoidance response late in the conditioned stimulus. For the first half of the biphasic effect the C.A.R. is inhibited and a response will escape/

[2] Phenylethylamines in the form of the hydrochloride salt and tryptamines in the form of the hydrogen oxalate.

/escape shock rather than avoid it. The resulting increase in reaction time (RT) will give a positive D-$\overline{S}$ score. In the second half of the biphasic effect the animal will cross immediately on the presentation of the conditioned stimulus. Thus there is a decrease in reaction time and a negative D-$\overline{S}$ score. In the main, smaller doses produce only a reduction in reaction time. No non-hallucinogens tested so far demonstrate these properties.

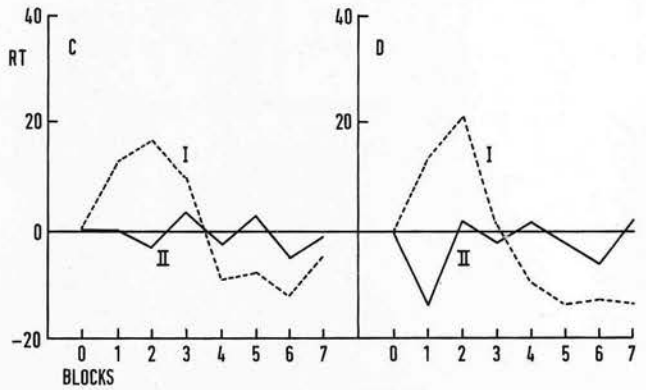
Fig. 38A compares the action of 5-methoxy-dopamine at two different dose levels, 50 and 25 mg/kg. This compound produces merely an inhibition of the CAR. Fig. 38B illustrates the less severe but similar inhibition induced by dopamine. It has been reported that 5-hydroxy-dopamine causes a greater inhibition of rope-climbing behaviour in the rat than does dopamine itself. (Smythies etal. 1960). The increase in activity is also manifested in our data when a methoxy-group is substituted in the 5-position. Fig. 38C demonstrates the decline in activity of mescaline when the 4-methoxy-group is removed and replaced by OH. The inactivity of the resulting compound at 50 mg/kg can be compared with 25 mg/kg mescaline which produces the specific hallucinogenic biphasic profile on this test. Similarly, Fig. 38D illustrates a comparable reduction in mescaline activity following substitution of the 5-methoxy group by OH.

Since it is unlikely that these hydroxylated compounds can cross the blood-brain barrier, they might be active if/



I. 25mg/kg 3,4-Dihydroxy-5-Methoxyphenethylamine I. 25mg/kg 3,4-Dihydroxyphenethylamine (DOPAMINE)

II. 50mg/kg 3,4-Dihydroxy-5-Methoxyphenethylamine II. 50mg/kg 3,4-Dihydroxyphenethylamine (DOPAMINE)



I. 25mg/kg 3,4,5-Trimethoxyphenethylamine (MESCALINE)

II. 50mg/kg 3,5-Dimethoxy-4-Hydroxyphenethylamine

I 25mg/kg 3,4,5-Trimethoxyphenethylamine (MESCALINE)

II 50mg/kg 3,4-Dimethoxy-5-Hydroxyphenethylamine

FIGURE [38]

Comparison of the effects of Mescaline and three Analogues. Abscissa: Blocks of 20 trials each. Ordinate: Mean change in Reaction Time in secs. Each point represents the total reaction time for a block of 20 trials, averaged over 4 animals.

/if injected intrathecally. Furthermore, it is probable that the inhibitory effect of the dihydroxylated compounds may be due to some peripheral action.

In Fig. 39, the behavioural effects of two close analogues of N,N-dimethyltryptamine are presented. Fig. 39A and C show the action of 5 and 10 mg/kg 5-methoxy-N-methyltryptamine respectively, each compared with a similar dose of N,N-dimethyltryptamine. In a similar fashion Fig. 39B and D compare the effects of 5-methoxy-N,N-dimethyltryptamine and N,N-dimethyltryptamine. These results show clearly the biphasic profile produced by N,N-dimethyltryptamine. Also evident is the more rapid onset and increased effect of this drug over mescaline in both halves of the biphasic response, but with a shorter lasting inhibitory action. Szara (1957) has shown that in man DMT produces a more intense, shorter acting effect than mescaline with a more rapid onset, so these results obtained using the rat seem to be comparable.

Fig. 39B and D suggest that 5-methoxy-N,N-dimethyltryptamine could be a more potent hallucinogen than DMT, as the biphasic effect produced is greater than that caused by the same dose level of DMT.

Benington, Morin and Clark (1965) have examined some of the pharmacological and behavioural properties of this drug and predict that it will be an hallucinogen in man. This/

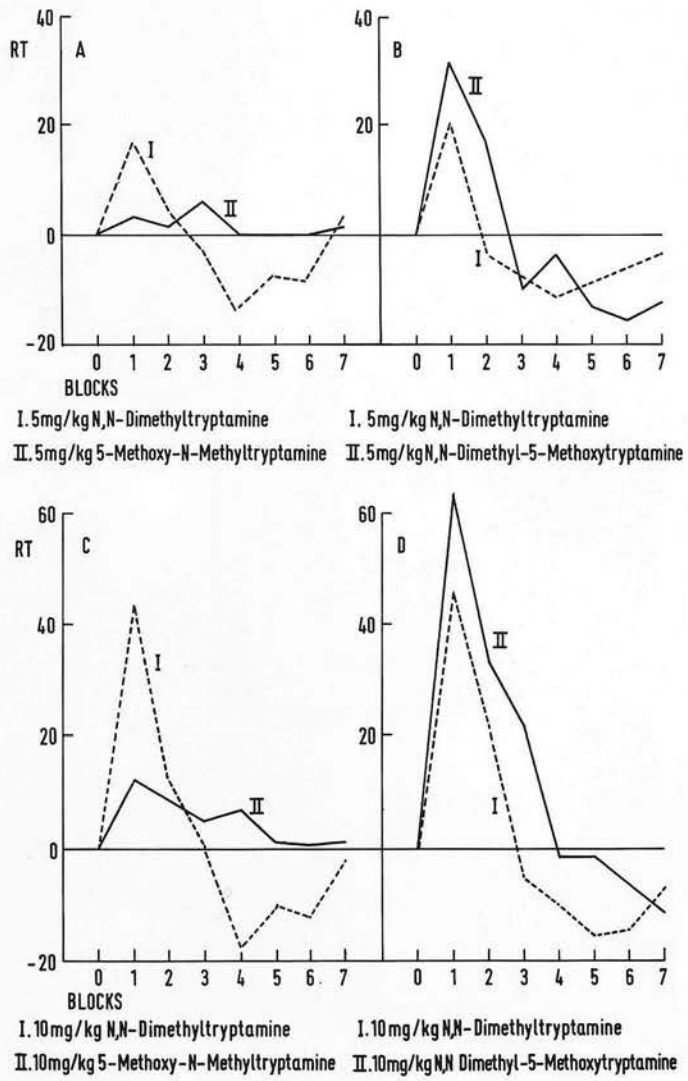


FIGURE [39]

Comparison of the effects of N,N-DMT and two Analogues. Abscissa: Blocks of 20 trials each. Ordinate: Mean change in Reaction Time in secs. Each point represents the total reaction time for a block of 20 trials, averaged over 4 animals.

/This prediction is supported by the fact that certain Indian tribes in South America take an hallucinogenic snuff (Epena), which has been found to contain 5-methoxy DMT as a major component together with small quantities of DMT and bufotenine (Holmstedt, 1967).

Fig. 39A and C show that the closely related substance 5-methoxy-N-methyltryptamine is relatively inactive, producing only a slight inhibitory effect at 10 mg/kg.

The raw data from both Figures 38 and 39 can be examined in Table 20.

RAW DATA FROM FIGURE [38]

		1	2	3	4	5	6	7
A	I	20.0	21.6	3.9	2.6	5.1	1.3	1.5
	II	38.7	37.4	27.6	15.1	12.3	-1.1	0.0
B	I	10.6	3.9	1.8	2.7	-1.6	2.4	0.0
	II	34.2	30.8	26.4	14.0	20.8	24.0	9.5
C	I	12.7	16.3	10.0	-9.2	8.1	12.1	4.8
	II	0.4	-3.7	3.9	-2.4	3.2	-5.3	-1.4
D	I	14.7	20.3	2.0	-9.8	-13.8	-12.2	-13.6
	II	-13.6	2.2	-2.1	2.2	-2.3	-6.4	2.2

RAW DATA FROM FIGURE [39]

		1	2	3	4	5	6	7
A	I	16.4	4.3	-3.0	-13.9	-7.3	-8.8	3.4
	II	3.9	1.5	6.1	0.2	0.0	0.1	1.7
B	I	20.0	-3.2	-7.9	-13.7	-8.2	-6.0	-3.9
	II	29.4	16.4	-9.8	-3.8	-13.5	-15.9	-11.4
C	I	43.6	12.3	0.9	-17.4	-10.1	-12.1	-1.8
	II	11.9	9.2	4.8	6.9	1.7	1.5	1.8
D	I	43.8	21.6	-5.2	-9.9	-15.1	-13.8	-7.0
	II	63.4	32.4	21.2	-1.7	-1.6	-6.0	-11.2

TABLE [20]

Average total change in reaction time (RT) in secs. i.e. $(D - \bar{S})$ for each of the 7 blocks of 20 trials as shown in Figs. [38] and [39].

E X P E R I M E N T 18

In a search for other possible hallucinogenic derivatives of tryptamine a further structure activity relationship study of the tryptamine molecule was carried out. Three types of compound were examined: (1) 3-(2-dialkyl-aminoethyl) indoles, (2) 3-(2-alkyl-aminoethyl) indoles and (3) 3-(2-dialkylaminoethyl)-2-methylindoles. The following is a list of trivial names for the compounds tested in the order appearing in Figure 40.

I. (N,N-diISOpropyltryptamine) HCL.

II. (3-(2-tetrahydropyrrolethyl)-indole) HCL Picrate.

III. (3-(2-piperidinoethyl)-indole) HCL Picrate.

IV. (N,N-dipropyltryptamine) HCL.

V. (N,N-diethyltryptamine) HCL Picrate.

VI. (N,N-dimethyltryptamine) Fumarate Picrate.

VII. (N,N-dibutyltryptamine) HCL.

VIII. (N-butyltryptamine) HCL.

IX. (N-propyltryptamine) HCL.

X. (N-ethyltryptamine) HCL Picrate.

XI. (N-methyltryptamine) HCL Picrate.

XII. (N,N-diethyl-2-methyltryptamine) HCL Picrate.

XIII. (3-(2-morpholinoethyl)-indole) HCL Picrate.

With the exception of compounds V and VI none of these analogues has been previously investigated on/

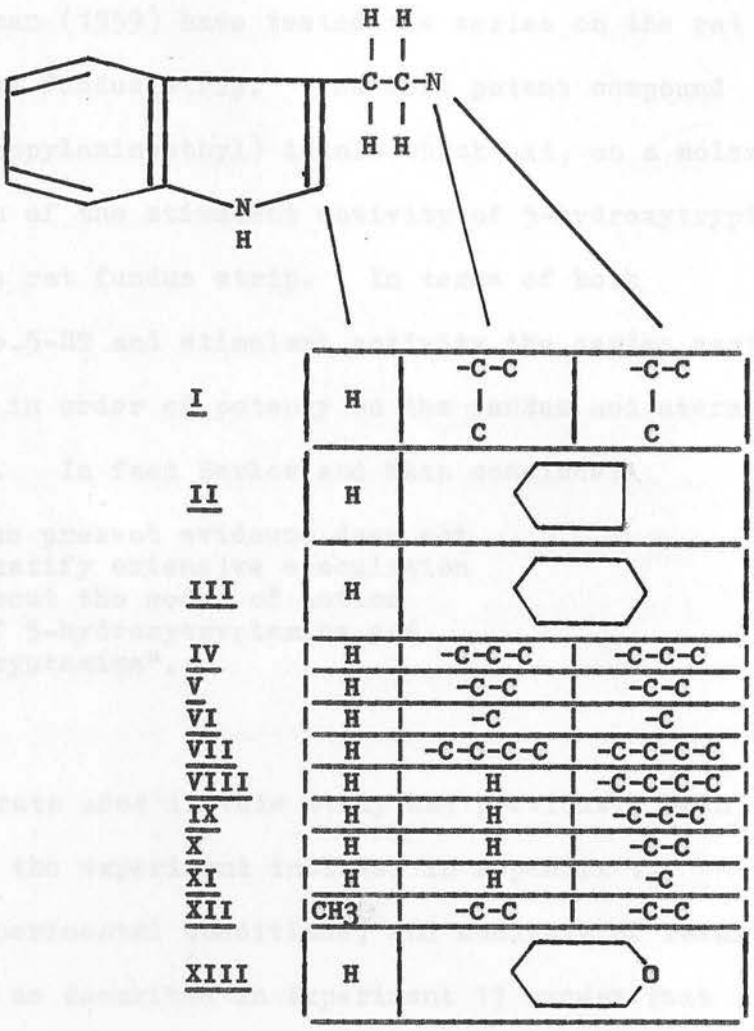


FIGURE [40]

Thirteen derivatives of Tryptamine.

/on either animal or human behaviour. However, Barlow and Khan (1959) have tested the series on the rat uterus and rat fundus strip. The most potent compound was 3-(2-dipropylaminoethyl) indole which had, on a molar basis, 1/40th of the stimulant activity of 5-hydroxytryptamine (5-HT) on the rat fundus strip. In terms of both antagonism to 5-HT and stimulant activity the series varied considerably in order of potency on the fundus and uterus preparations. In fact Barlow and Khan conclude:-

> "The present evidence does not justify extensive speculation about the modes of action of 5-hydroxytryptamine and tryptamine".

METHOD

The 10 rats used in this study had previously been subjects for the experiment included in Appendix 1. Training, experimental conditions, and analysis of results were exactly as described in Experiment 17 except that all drugs were given at two dose levels, 5 mg/kg and 10 mg/kg. Two different animals were subjected to each drug dosage in a balanced design. Due to solubility difficulties all drugs were injected in a volume of 1 ml. isotonic saline. 14 days were allowed between drug treatments in order to counteract any tolerance effects.

RESULTS

The rank in which the compounds are listed in Figure 40/

/Figure 40 is an approximate estimation of the actual order of potency as determined by this experiment. Out of 13 analogues in the series only 6 were active. These were compounds I to VI listed in decreasing order of potency. (Table 21). Compounds VII to XIII were totally inactive at 5 mg/kg and 10 mg/kg.

Perhaps the most interesting result is the powerful disruptive action of compound I (N,N-diISOpropyltryptamine). This is contrary to the findings of Barlow and Khan who reported that the normal isomer, IV (N,N-dipropyltryptamine) was the most potent of the series which they had tested.

This behavioural study is in agreement with Barlow and Khan, in that dipropyl substitution produces a more potent compound than either diethyl or dimethyl substitution. It is not clear whether these dipropyl compounds are the most active members of the 3-(2-dialkylamino-ethyl) indoles because the propyl group is specifically associated with activity, or simply because the size of that part of the molecule has reached a critical limit. For example, increased alkylation to di-butyl substitution VII renders the compound inactive. In terms of lipid solubility the partition coefficients of these compounds increased with progressive alkylation, therefore N,N-dibutyltryptamine VII will be the most penetrative compound of all - but it is inactive. Taborsky etal. (1966) have arrived at a/

		1	2	3	4	5	6	7
I	1	68.3	75.5	48.1	52.7	43.6	11.2	34.7
	2	81.9	25.3	19.4	-6.2	11.3	-8.4	-21.6
II	1	54.8	39.9	47.6	21.3	13.3	-4.6	-11.3
	2	26.8	31.1	14.5	-18.7	-43.6	3.4	-8.1
III	1	46.6	31.8	5.3	-1.7	3.8	-7.4	2.9
	2	38.6	44.3	9.9	-4.3	-11.2	0.0	-4.2
IV	1	27.9	35.6	10.8	6.2	-11.6	-25.2	-14.4
	2	18.5	14.9	-1.6	4.1	-6.6	5.1	-16.3
V	1	32.7	10.4	-1.7	-6.5	1.3	2.6	-3.1
	2	6.2	18.1	-9.3	-14.9	-53.6	-3.4	6.2
VI	1	23.6	-6.2	-1.4	-8.2	-2.0	1.4	0.6
	2	7.8	-1.6	-8.3	4.3	10.1	0.0	-4.5

TABLE [21]

Average total $(D - \bar{S})$ score for each of the 7 blocks of 20 trials. Two rats at 2 different dose levels for the six active compounds shown in Fig. [40] i.e. I to VI.

1 - 10mg/kg.
2 - 5mg/kg.

/a similar dilemma when trying to explain the fall-off in activity with increased alkylation in the 1-position for an N,N-dimethyltryptamine series. However, there is evidence in the literature for antimicrobials and other such agents, that increased lipid solubility or a more favourable organic-water distribution reaches an optimal value (Taborsky and Starkey, 1963; Block, 1954; Byrde etal. 1958). Hansch and Fujita (1964) have shown that further increase of partitioning into the lipid over the aqueous phase, results in trapping of the molecule in the lipoidal areas of the organism and of its cell membranes, thus reducing its effects. This would explain the inactivity of N,N-dibutyltryptamine and also the fact that N,N-diISO-propyltryptamine I is more active than N,N-dipropyltryptamine IV. There are no theoretical reasons why the tetra-hydropyrrol II and piperadino III derivatives should be active. Perhaps transport is unimportant in their case and potency is a function of some complex bulk or charge phenomena at the receptor site.

All four mono N-substituted compounds were inactive i.e. VIII to XI. Bradley and Loose (1967) have shown that mono N-substitution in the tryptamine series induces very low lipid solubility characteristics so compounds VIII to XI will probably not penetrate the CNS. The asymmetrical conformation of these compounds would/

/would confound the possibility of entering the fatty acid chains which are arranged longitudinally in membranous material of a lipoid nature.

Compound XII was inactive and there is no simple explanation why this should be so. In contrast to the results of Gaddum etal. (1955), Barlow and Khan (1959) showed that this 2-methyl substitution did not increase the antagonistic activity although there was a certain increase of specificity for 5-HT.

Compound XIII 3-(2-morpholinoethyl)-indole, also found to be inactive in this experiment, was one of the few inactive compounds described by Barlow and Khan.

CHAPTER 7

DISCUSSION AND CONCLUSIONS OF THE DRUG EXPERIMENTS

C H A P T E R 7

7.1 The inactivity of CPZ at doses up to 2 mg/kg in Experiment 15 is in marked contrast to the report by Berryman etal. (1960) who found that 0.2 mg/kg CPZ produced disruption on a positive reinforcement baseline in the rat. This result may therefore give further support to the evidence for schedule specific effects as propounded by Ray and Bivens (1966).

The discrepancy between effective dose (ED) values on negative and positive reinforcement schedules may be explained by the drug alteration of reinforcement thresholds. For example, amphetamine may abolish a positive reinforcement baseline because of its properties as an anorexic drug. (Teitelbaum and Derks, 1959; Weissman, 1959). Similarly, for a variety of reasons, but mainly because of clinical evidence, CPZ may be thought to alter the control exerted by an aversive stimulus. To express this in another way, CPZ may block the avoidance response but not the escape response (Domino etal. 1963).

Dews (1955a, 1958a,b) and Morse and Herrnstein (1956) have suggested that behaviour controlled by internal stimuli may be more sensitive to modification by drugs than behaviour controlled by external environmental stimuli. Laties and Weiss (1966) have shown that CPZ seems to have/

/have no differential effect upon schedule components under external or "internal" stimulus control. In the same experiment they found that amphetamine was more likely to produce effects when no external stimuli were involved in the control of schedule performance. The effects of 2 mg/kg amphetamine in Experiment 15 are in agreement with this finding and verify the reported abolition of collateral behaviour by Laties and Weiss (1965). It could be hypothesized that amphetamine causes anIRT distribution shift during DRL because it generates behaviour which is incompatible with collateral activity. Bradley (1967) trained four rats on a discriminated DRL 15 schedule until almost all responses satisfied the DRL requirement. Only one of these animals showed any form of collateral behaviour. After each reinforcement the rat would gnaw a bar in the shock-grid in the front right-hand corner of the chamber. This gnawing was continued until the S^D was presented (15 secs. later) and immediately after S^D onset the lever was pressed. For all four subjects the baselines were indistinguishable but the behaviour of one animal was mediated by a chained response. It was possible to abolish this collateral gnawing by covering the floor of the chamber with a metal sheet. On such occasions the IRT distribution was shifted to the left and most responses were emitted prior to onset of the S^D. As in Experiment 15, 2mg/kg/

/2mg/kg amphetamine also had a disruptive effect on the performance of this rat i.e. gnawing disappeared and the mean IRT was shifted to below the lower bound of the S^D. However, up to 4 mg/kg amphetamine had little or no effect on IRT production for the other 3 animals.

The similarity in structure between mescaline and amphetamine would suggest that both drugs might act in comparable ways and there is considerable evidence that their effects are qualitatively similar in the human subject (Malitz, 1966). However, in Experiment 15 this is not the case. Mescaline, although more likely to cross the blood-brain barrier because of its ring-methoxy groups, shows only 1/6th the activity of amphetamine. Also the forms of the two responses are quite different. Mescaline does not interfere with overall IRT characteristics. At 8.5 mg/kg it is inactive but at 12.5 mg/kg there is a period of inhibition followed by a complete and almost instantaneous return to normality. This drug effect is not apparent from either 0 order or 1st order IRT distributions (Table 17) but is very obvious on inspection of the cumulative record (Figure 33).

The great problem of aversive properties versus control by external and internal stimuli, in the explanation of any drug effect, becomes even more remote when certain physiological factors are examined. It is known that/

/that aggregating mice within a confined space increases behavioural excitement and potentiates the lethality of amphetamine (Chance, 1946; Gunn and Gurd, 1940). Weiss and Laties (1961) have confirmed this increase in amphetamine potency in the rat, using an avoidance baseline. They also demonstrated that CPZ, phenoxybenzamine and adrenalectomy, counteracted the effect. These facts suggest that endogenous catecholamines are implicated in the increased toxicity of amphetamine in stressed animals. Adrenergic blocking agents (Maxwell, 1959; Weiss etal. 1961) and reserpine pretreatment (Lasagna and McCann, 1957; Burn and Hobbs, 1958) protect against aggregated amphetamine toxicity while pretreatment with monoamine oxidase inhibitors blocks the protective actions of reserpine (Halpern etal. 1962). Furthermore, it has been demonstrated that d-amphetamine causes partial depletion of brain and heart stores of norepinephrine and that aggregation enhances this release. (Moore, 1963). More recently it has been shown that α-methyl-m-tryosine a selective depletor of norephinephrine in brain also reduces the toxicity of amphetamine during aggregation (Lal etal. 1963; Moore, 1964). This phenomenon is one of those rare observations from animal psychopharmacology which has made a useful contribution to biological research. A similar finding has been made in Experiment 15 when 1 mg/kg amphetamine had no/

/no effect upon a DRL15LH5 baseline, whereas Johnston and Bradley (1967) have demonstrated severe disruption at 1 mg/kg on discriminated Sidman avoidance.

The situation is even more complicated by the fact that other drugs are decreased in potency after the introduction of aversive parameters. Bousquet etal. (1965) have shown that the duration of response to hexobarbital, pentobarbital, meprobamate and zoxazolamine is significantly reduced in stressed animals, as measured by period of loss of the righting reflex. It was not possible to influence the duration of response to these drugs in adrenalectomized, hypophysectomized or morphine-pretreated rats, suggesting that the effects of stress on the drug response were mediated over the pituitary-adrenal axis and by way of the catecholamines.

The amphetamine - aggregation interaction can be explained by the cumulative effect of both the stressor properties of the drug and the normal physiological reaction to crowding. (Thiessen, 1964). Known responses to drugs include pituitary mediated reactions such as hypersecretion of ACTH, an increase in blood corticoids and a depletion of both adrenal ascorbic acid and adrenal cholesterol.

Other metabolic consequences of stimulation of the pituitary-adrenal axis include a corticosteroid-induced/

/induced synthesis of many liver enzymes responsible for carbohydrate and amino acid metabolism, including tryptophan pyrrolase, tyrosine transaminase and gycogen synthetase (Knox, 1963; Sie and Fishman, 1964). Rosen and Nichol (1963) have pointed out that drugs, acting as chemical stressors, also induce synthesis of such enzymes. Therefore biochemical mobilization might explain the decrease in drug activity due to stress as described by Bousquet etal. (1965). It is possible that the decrease in potency only applies to peripheral drug effects i.e. on the righting reflex. This is confirmed by the observation that 25 mg/kg mescaline has a direct effect at the neuromuscular junction (Schopp etal. 1961) inducing marked paralysis in animals on positive reinforcement schedules. However, the same dosage given to animals on an avoidance schedule (Smythies etal. 1967), although disrupting baseline performance, has no effect on motor activity. On the basis of such a finding it could be hypothesized that animals on positive reinforcement schedules would show a decreased response to mescaline if subjected to aversive stimulation. This is not the case, and Smythies etal. (1967a) have shown that animals on positive reinforcement baselines show increases in sensitivity to mescaline action after stabilization of the conditioned emotional response (Estes and Skinner, 1941).

7.2 In Experiment 16 it has been shown that the acid, alcohol, N-methyl and β-hydroxy derivatives of mescaline are inactive in doses up to 25 mg/kg (I.P.) in the rat. Friedhoff and Goldstein (1962) have claimed that the aldehyde or alcohol derivative could be the active metabolite of mescaline and found the alcohol to be active in the rabbit when administered I.V. All injections in the experiments described here were given intraperitoneally and it may well be that drugs given by different routes would have different effects. Westermann (1961) describes how the variations in effect of compounds depends on the route of administration. I.P. injections are absorbed directly into the portal system, and so a drug may be completely inactivated on its first passage through the liver. There is still a great deal of basic work to be carried out on drug absorption and detoxification at various sites, especially on the several aspects of the blood-brain barrier phenomena.

The ability of a compound to penetrate the blood-brain barrier must be an important factor in its capacity to disrupt behaviour. It has been shown that this is correlated with lipid solubility as measured by the lipid solvent-water partition coefficient. For example, serotonin (5-hydroxytryptamine) has a low lipid solubility/

/solubility and does not enter brain except when given in very large doses. However, tryptophan, the non-hydroxylated precursor of 5-HT, has a behavioural effect because it reaches brain and is subsequently converted to 5-HT. Tryptamine itself enters brain readily and is quite inactive, thus the hydrophilic hydroxy-group of 5-HT has an important function but precludes the entry of exogenous 5-HT into brain. Similarly the ring hydroxylated derivatives of mescaline tested in Experiment 17 may have hallucinogenic properties and are only inactive because of their low lipid solubility.

Marley and Morse (1966) have described techniques for the conditioning of pecking behaviour in newly hatched chickens. The chicken is particularly interesting as an experimental subject because the maturation of the blood brain barrier does not take place until after four weeks. For example Key and Marley (1962) have studied the effects of systemic injections of amines into young chickens before and after the maturation occurs. They claimed that epinephrine given before the development of the blood brain barrier had the same effect as epinephrine given directly into the brain of the mature animal. This type of work would provide a useful test for the hydroxylated compounds which are found to be inactive in the rat.

/rat.

However, because an injected compound is found to be inactive, this does not preclude its role as a possible hallucinogenic metabolite of mescaline. The laws of transport may ensure that the exogenous compound will never reach an activating site - but if it is actually synthesised in the critical region of the neurone then it may activate that site before further detoxification takes place.

The 19 ring-methoxylated derivatives of mescaline were examined in Experiment 16 and in Appendix 1. Ortho, meta and para methoxy substituted compounds and all six di-substituted compounds (i.e. 2,3; 2,4; 2,5; 2,6; 3,4; 3,5) were inactive. Of the tri-substituted compounds, (2,3,4; 2,3,5; 2,3,6; 2,4,5; 2,4,6; and 3,4,5) all proved to be inactive except the last (mescaline itself). The only active tetra methoxy compound was the 2,3,4,5 substituted derivative - it was more potent than mescaline. 2,3,4,5,6-pentamethoxyphenylethylamine was by far the most active compound of the series. A dose of 6.25 mg/kg caused a disruption of behaviour comparable to the effect produced by 25 mg/kg mescaline.

From these results we can derive a number of general laws concerning the psychotomimetic properties of these compounds:/

/compounds:

(1) They must have at least three methoxy groups on the benzene ring

(2) These must be on the 3,4 and 5 positions (2,3,4 etc. are inactive)

(3) Increasing the number of groups increases the potency provided the 3,4 and 5 positions are filled (2,3,4,6 and 2,3,5,6 are not active).

How can these findings be explained? The first obvious suggestion is that the potency might be related to the susceptibility of the compounds to attack by amine oxidase. That is, those which are quickly metabolized are not hallucinogens and the compounds which are not broken down by amine oxidase <u>are</u> hallucinogens. Clark etal. (1965) have shown that, in vitro, the resistance to attack by amine oxidase depends on either both the 2 and 6 positions being filled or having more than three methoxy groups. If this was the whole story then 2,6 dimethoxy-phenethylamine should be hallucinogenic - that is not the case. However, their results might explain why the penta-methoxy and the 2,3,4,5 tetra-methoxy compounds are more potent hallucinogens than mescaline. That is, if we assume that the 3,4,5 configuration is necessary for psychotomimetic activity but having this, the strength of the hallucinogen depends on its resistance to/

/to destruction by mescaline oxidase - then mescaline would be relatively inactive. The 2,3,4,5 tetra-methoxy compound should be more active since it contains the four methoxy groups necessary for protection and finally, the 2,3,4,5,6 should be most active since it contains not only the four protective methoxy groups but also has the additional protection of the 2 and 6 positions being filled.

It could also be argued that any change in the molecular structure might effect some purely physical property of the compound, such as its lipid solubility and thus prevent it from reaching the brain. If this was the case then the active compounds should have a higher lipid solubility than the inactive ones. The partition coefficients shown in Table 19 verify this hypothesis, but also point out that the inactive tetra-methoxy analogues have a higher P.C. than mescaline itself. Therefore the molecular specificity of the 3,4 and 5- positions must be the crucial determinant of hallucinogenic potency. It may be noted that mescaline should not act through any deaminated metabolite, as has been suggested, since the α-methyl and penta-methoxy analogues are more active than mescaline and are not substrates for amine oxidase. It is also feasible that mescaline does not act through any indolic derivative as the penta-methoxy structure prevents indole formation. Furthermore, the possibility that the electron donating/

/donating capacity of the methoxy groups might activate adjacent sites on the ring, cannot be related to its behavioural effects because no such sites are available in the penta methoxy compound.

The introduction of an α-methyl group into the side chain of methoxylated β-phenethylamines is a manipulation of particular interest. Shulgin (1964) has reported that α-methyl derivatives have greater hallucinogenic activity than mescaline, whereas longer chain α-substitutions decrease potency. Furthermore, Shulgin noted that repositioning of a meta-methoxy group to an ortho-location in α-methyl mescaline augmented the hallucinogenic effect.

Smythies etal. (1967b) have tested a series of ring-methoxylated phenylisopropylamines (amphetamines) on an avoidance baseline in the rat. In the tri-methoxy amphetamines activity was in decreasing order: 2,4,5-$>$3, 4,5-$>$ 2,4,6-$\gg$2,3,4- where the 2,3,4- compound was almost inactive. A similar result was obtained in human studies by Shulgin (1964) who found the 2,4,5- compound to be 17 times as active an hallucinogen as mescaline, the 3,4,5- some 2X as active and the 2,3,4- compound to be inactive. In the dimethoxy series 2,3- 2,5- and 3,5- compounds were inactive but the 3,4- compound was highly potent, 12.5 mg/kg being roughly equivalent to 25 mg/kg mescaline. Meta and ortho compounds showed only moderate amphetamin-/

/amphetamine-like activity over a wide dose range but para-methoxy amphetamine (PMA) was the most potent hallucinogen of the series inducing severe and long lasting effects at 3.1 mg/kg. Therefore the results in this series are totally different from those in the phenethylamine series of Experiment 16. The present data would suggest the hypothesis that the essential feature of the 'hallucinogenic' molecule in this series is the para-methoxy group. The different results in the phenethylamine series may be due to the fact that the apparently inactive compounds may be too easily metabolised by amine oxidase to produce behavioural effects following parenteral injection. For example, Friedhoff and Hollister (1966) have shown that 3,4-dimethoxyphenylethylamine, which is inactive in man, is a much better substrate for amine oxidase than is mescaline. In the methoxylated amphetamine series the molecule is protected from amine oxidase by α-methylation, thus the behavioural reaction to the drug, injected parenterally, may more truly reflect activity at the site of action. Smythies etal. (1967b) tested this hypothesis by pretreating an animal with 50 mg/kg iproniazid 3 hours before injecting 6.2 mg/kg of para-methoxyphenylethylamine (PMPEA). (PMPEA was found to be inactive up to 25 mg/kg in Experiment 16 and may be given the alternative trivial formula O-methylparatyramine). Neither of these compounds given/

/given alone, produced the slightest effect, but when given together, behaviour was completely disrupted.

Several experiments have been reported where animals were pretreated with a monoamine oxidase inhibitor (iproniazid) prior to mescaline administration. Friedhoff and Goldstein (1962) gave 100 mg/kg iproniazid to rats, 24 hours and 3 hours before mescaline. This pretreatment had no effect upon the gross behavioural changes induced by mescaline at 10, 25 and 100 mg/kg. The iproniazid pretreatment itself had produced a slight behavioural excitation at the time of mescaline administration and urine estimations of labelled mescaline showed that levels of the unmetabolized amine were considerably increased. In vitro experiments suggest that monoamine oxidase does not affect the metabolism of mescaline, however diamine oxidase (histamine oxidase) and a specific mescaline oxidase (found in rabbit liver) are probably involved in the oxidation. Since iproniazid is not a specific MAOI and is capable of inhibiting both histamine and mescaline oxidase this would explain the increase in unmetabolized mescaline in urine. Goldwurm and Gualandri (1963) found that pretreatment with iproniazid abolished the inhibitory action of mescaline on shuttle box avoidance in the rat. Steiner and Sulman (1963) using rabbits reported that iproniazid given prior to mescaline induced an anxiety reaction/

/reaction together with EEG changes. Using an avoidance baseline in the rat Smythies etal. (1967c) have demonstrated conclusively that iproniazid pretreatment produces a marked increase in the response to mescaline. However, when estimating the effects of MAOIs given as a pretreatment to mescaline, the alternative hypothesis must be evaluated, that the increased levels of other cerebral monoamines in some way facilitate the hallucinogenic activity of mescaline. A number of experiments are suggested by the latter consideration. If endogenous amine levels are involved then pretreatment with amine depletors such as reserpine or tetrabenazine should decrease hallucinogenic activity and specific MAOIs (possibly N-octanol) should enhance hallucinogenic activity. Since pharmacological agents are available which selectively interfere with the synthesis and metabolism of particular amines then it might be possible to further delineate the precise action of mescaline. Finally, with regard to the clinical significance of the above speculations recent reports by Boulton etal. (1967) and Jenner etal. (1967) that large amounts of paratyramine metabolites are being secreted by some schizophrenic patients, would tend to support the hypothesis that schizophrenia may be associated with 4-methoxylation of catecholamines or tyramine. The data suggests that O-methyl tyramine produced/

produced at the synapse (separated from MAO) would have profound effects on behaviour and the fact that 3,4-dimethoxyphenylethylamine (DMPEA) is inactive in humans may be due to its rapid breakdown by MAO.

7.3 Szara (1961) and Szara and Hearst (1962) have postulated, on the basis of chromatography, that the 6-hydroxylation of tryptamine derivatives may be a possible pathway for the production of psychoactive metabolites. Szara was led to this position by the indentification of an enzyme in rabbit liver microsomes that could hydroxylate and N-demethylate DMT (Szara and Axelrod, 1959). From the urine of rats given DMT they isolated a product which they first believed was 7-hydroxyindoleacetic acid, but later showed was 6-hydroxyindoleacetic acid. Szara (1964) then found that the liver microsomal system could 6-hydroxylate the lower homologues of the dialkylated tryptamine series DMT, DET and N,N-dipropyltryptamine, all of which were psychotomimetic, while dibutyl- and dihexyltryptamines were not 6-hydroxylated and were behaviourally inactive. Szara further strengthened his case by showing that 6-hydroxy DET was more potent than DET in the monkey and by demonstrating a positive correlation between urinary excretion of the 6-hydroxy metabolite and psychotomimetic effect in man (Szara etal. 1962; Szara, 1961). More recently this theory has been criticized by Rosenberg etal. (1963), Taborsky etal. (1966) and Taborsky etal. (1967) who all proved that 6-hydroxy N,N-dialkylated tryptamines were behaviourally inactive in several species including man. However, such experiments cannot constitute a/

/a valid criticism unless comparative rates of degradation and relative penetration rates into brain are studied. 6-hydroxy DMT may be the hallucinogenic metabolite of DMT but by reason of its phenolic hydroxy group it may not cross the blood brain barrier if injected parenterally. The difficulty may lie in the estimation techniques which Szara originally employed. Structural isomers in which hydroxylation occurs in a position other than 6 might be difficult to distinguish from each other on chromatography. This has recently been shown to be true in the case of skatole where the 6-hydroxylated metabolite was previously thought to be the major one excreted in man (Horning etal. 1959). Development of new gas chromatographic procedures, new availability of synthetic standards, and study of the colour reactions of hydroxylated skatoles has shown a mixture of the 5-, 6-, and 7-hydroxylated skatole isomers to occur in man (Heacock etal. 1964). Taborsky etal. (1966) have shown that 5-methoxytryptophol acetate is not 6-hydroxylated in the rat. It might then be concluded that Szara's 6-hydroxylation theory is'not proven' but must be judged in terms of the large amount of research and interest which it has aroused.

In the investigation of the tryptamine molecule described in Experiments 17 and 18 it has been shown that all the mono N-alkylated derivatives of tryptamine are/

/are inactive in the rat. It was hypothesised that lipid solubility characteristics might explain this reduction of potency. It is notable that the obvious increase in lipid solubility accrued by 5-methoxy substitution in N-methyltryptamine giving 5-methoxy-N-methyltryptamine (Exp.17) produced a very slight inhibition of the avoidance response at 10 mg/kg. There is little subsidiary pharmacological evidence on which to base any further speculation as to the possible mode of action of the hallucinogenic tryptamines. The results of Barlow and Khan (1959) and Gyermek and Bindler (1962) show that the 'in vitro' effects of tryptamine derivatives bear relationship to the behavioural disruption demonstrated in this thesis and by other authors.

It was suggested that the inactivity of compounds further alkylated beyond N,N-dipropyl substitution might be due to a rise in lipid solubility above optimal levels and subsequent trapping of the molecule in lipid membranes. Benington (1967) has shown that 5-benzyloxy-N,N-dimethyltryptamine is many times more potent than DMT therefore this obviously very great increase in lipid solubility due to the benzyloxy substituent has not decreased the potency. This may then be evidence in favour of some explanation other than super-solubility. The most interesting compound of the series was 5-methoxy-N,N-dimethyltryptamine (5-MeoDMT) the O- and N-methyl derivatives of 5-hydroxytryptamine./

/5-hydroxytryptamine. Axelrod (1961) found that serotonin and tryptamine are enzymatically N-methylated to form the psychotomimetic metabolites bufotenine and DMT. Furthermore, dihydroxyindoles have been found to be O-methylated in the 5- and 6- positions by catechol-O-methyltransferase (Axelrod and Lerner, 1963). If human experimentation verifies the hallucinogenic propensity of this molecule then it might easily be thought to merit consideration as an endogenous psychotoxin derived from 5-HT by the above reactions. Takeo and Himwich (1967) have shown that 5-MeoDMT produces EEG arousal patterns at the medullary level as do most psychotomimetic catecholamines and indoleamines. (Takeo and Himwich, 1965). It has recently been discovered that sheep poisoning by strains of phalaris tuberosa L. in Australian pastures is caused by the presence of large quantities of 5-MeoDMT and bufotenine in this herbage (Oram and Williams, 1967).

It may be hypothesized on the basis of Experiment 18 that the previously untested compounds 3-(2-tetrahydropyrrolethyl)-indole and 3-(2-piperidinoethyl)-indole will be potent hallucinogens in man. Another significant finding is the fact that the iso configuration produces a more potent compound than the normal configuration in the N,N-dipropyltryptamine molecule.

7.4 This thesis has placed especial emphasis upon the nature of IRT generation within a DRLLH schedule. Perhaps an interested reader may turn to the serial probabilities listed in the Computer Appendices and uncover relationships which were left undetected by the present author. The use of the high speed digital computer in the analysis of IRT data should open up a whole new vista for the experimental analysis of behaviour. Unfortunately, as with all sophisticated equipment, the computer is a perpetual source of reinforcement and psychology will have to contend with yet another revolution. The computer revolution may be typified by the nonchalant application of wasteful and inappropriate mathematical techniques worked out at great speed and expense and with an appropriate lack of experimenter participation. However, simple probability calculations derived from serial IRT data should provide a host of new experimental ideas and explanations for the behavioural scientist.

At present, the use of operant techniques in pharmacological research is accelerating and may herald one of the most rewarding areas for interdisciplinary research. There is unfortunately no such thing as interdisciplinary science, there are only interdisciplinary scientists. It is pure fiction to imagine groups of/

/of psychologists, pharmacologists, biochemists, physicists, mathematicians and clinicians all working productively and in perfect harmony.

It is necessary to have an interdisciplinary mind in order to pose a meaningful interdisciplinary question and the formulation of that question is such, that only a scientist of wide experience can understand the terms of reference and in turn question the primary assumptions. This situation illustrates a peculiar virtue of interdisciplinary study in that a practitioner in one scientific discipline may be, through his inability to comprehend the traditions and approaches of another science, able to question its basic postulates and reformulate its problems in a new and useful way. As yet, psychologists have not made such a contribution to pharmacology.

Recent developments in psychopharmacology have favoured the appearance of so-called pretreatment experiments. That is, the modification of drug effects by prior treatment with other pharmacological agents. The most popular pretreatment compounds have been the MAOIs and on the basis of the pretreatment effect it is possible to hypothesise as to the nature of the pharmacological activity of the compound under investigation. A great deal of spurious theory and subsequent sterility of experimentation has arisen from the fact that some/

/some behavioural pharmacologists understand little about MAO and even less about drug receptor interaction. MAO was discovered in 1928 and still, the best preparation of the enzyme are impure and we know nothing of its kinetics or cofactor. It may even be a combination of many enzymes, but all we know is that the oxidation can be inhibited by certain compounds (MAOIs). As regards the receptor site, Paton (1967) has reviewed the relevant literature and concludes,

> "This situation has made me become increasingly dubious whether we can with confidence make answers even to the simplest questions about the interaction of sympathetic amines with their receptors".

The pharmacologist may turn to a physiologist for advice about the stability and sensitivity of his rat fundus strip, or other bioassay preparation. It is the function of the behavioural scientist to ensure that the pharmacologist can turn to <u>him</u> for information about behavioural baselines.

APPENDIX 1

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Structure-Activity Relationship Studies on Mescaline

III. The Influence of the Methoxy Groups

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Introduction

In previous studies (Smythies and Sykes, 1963) we have devised a test in animals predictive of psychotomimetic activity in man. This test was then used to investigate two compounds of current general interest (Smythies and Sykes, 1965). The present study is an investigation of the effect of the number and configuration of the methoxy groups on the phenylethylamine molecule. Two behavioural indices were used in this study. A discrete trial avoidance technique in a Shuttle box and the more complex continuous avoidance schedule in a Skinner box.

The 3, 4, 5 substitution of phenylethylamine by methoxy groups produces, of course, the active compound mescaline. It has also been reported that the 3,4 compound is inactive, both on animal tests (Smythies and Sykes, 1965; Appel and Freedman, 1966) and in man (Shulgin, 1966; Vojtechovsky, 1966; Hollister and Friedhoff, 1966). Previous investigations of this class of compound were carried out by Noteboom (1934), de Jong (1945) and Ernst (1965). Their criterion was the presence or absence of "catatonia" or a "Hypokinetic rigid syndrome". They reported that various compounds produced this state. However, the doses used were all very large and such that might have some direct effect on the neuromuscular junction (Schopp *et al.*, 1961). Consequently, their experimental data is not relevant to the study of the central effect of these drugs.

Method

Subjects

19 experimentally naive male hooded rats, supplied by the National Institute of Medical Research, were used in this study. The animals were approximately 100 days old at the beginning of the experiment, and were allowed food and water ad libitum.

Apparatus

Two modified Levine shuttle-boxes and a Skinner box were used. These experimental chambers were enclosed in ventilated and sound-proofed chests and all experimental contingencies were controlled by a system of relays and timers in an adjacent room. The behaviour was recorded on event recorders, counters, print-out counters and a cumulative recorder. Two behavioural schedules were used in the experiment, discrete trial avoidance in the shuttle box and discriminated Sidman Avoidance in the Skinner box.

Procedure

I. Shuttle-Box Discrete Trial Avoidance

In this part of the investigation a similar technique was used as in previous studies in this series (SMYTHIES and SYKES, 1963, 1966; SMYTHIES *et al.*, 1966). The animal was required to cross from one side of the shuttle-box to the other in response to a conditioned stimulus. The conditioned stimulus (a buzzer) sounded for 5 sec, at the end of which time the unconditioned stimulus (electric shock of 1.0 mA) was presented if the animal had failed to terminate the CS by a cross. A 2 hour experimental session consisted of seven runs of 20 trials each, the runs being separated by a time interval of 5 min.

16 animals were trained to an 85% avoidance criterion on this schedule. On drug days, intraperitoneal injections of either drug or saline were given after 40 trials: i.e. 2 runs of 20 trials allowing the animal to become acclimatized to the experimental situation. The seven sets of 20 trials then continued as on training days. As before, the results for each run of 20 trials are expressed in $D-\bar{S}$ scores (derived as described in SMYTHIES and SYKES, 1965): i.e. the difference between the drug score and the mean of the pre-drug and post-drug saline scores. Initially the response to 25 mg/kg mescaline was determined for each animal. Then the series of ring-methoxylated β-phenylethylamines was tested at two dose levels, 12.5 mg/kg and 25 mg/kg. Pentamethoxy-β-phenylethylamine which was found to be very active was also tested at 3.125 mg/kg and 6.25 mg/kg. Four animals received each dose level of a given drug according to a random design, and a fortnight was allowed between every drug treatment.

II. Skinner Box Continuous Avoidance

The remaining 3 animals were extensively trained on a discriminated Sidman avoidance schedule with a response-shock interval of 30 sec and a shock-shock interval of 10 sec. On this schedule an animal receives a shock lasting 0.5 sec every 10 sec unless it makes a bar-press which postpones the next shock for 30 sec. During the last 10 sec of this response-shock interval a discriminative stimulus is turned on inside the experi-

mental chamber. The stimulus light remains on until the animal makes a response which initiates a new cycle. At the end of the training period all animals had reached a stable level of performance with the majority of their responses occurring within the discriminative stimulus period.

Throughout the experiment each subject was tested at the same time every day for $2\,^3/_4$ hours. The experimental session can be subdivided into a 15 min 'warm-up' period, 30 min pre-injection or control period and a 2 hour test period. Each subject served as his own control and was injected with a control physiological saline solution on the pre and post drug days. Drugs were given after the pre-injection period and the subject was immediately placed in the Skinner box for the 2 hour test period.

Initially, 25 mg/kg mescaline was administered to all subjects, then each animal was subjected to a different drug sequence with 14 days between each drug administration. The experiment was designed so that each drug result was replicated on two different animals. Finally, each animal received a further 25 mg/kg mescaline.

The data are presented in the form of cumulative records showing clearly how the 3 active compounds inhibit bar-pressing (Fig. 1). However, this method of presenting the data by itself would not distinguish between a hallucinogen and, say, a phenothiazine. Therefore inter-response times were printed out sequentially by a print-out counter, thus giving information as to the timing of the response in the experimental cycle. There are 3 types of response possible:

1. *A premature response:* i.e. one before the onset of the discriminative stimulus.

2. *An efficient response:* i.e. one occurring during the discriminative stimulus and before shock.

3. *A late response:* i.e. one occurring after the animal has taken shock.

Also measured was the *reaction time*, i.e. the interval between the onset of the discriminative stimulus and the lever press. The types of responses can be expressed as percentages of the total responses obtained. This technique was developed by BOVET and GATTI (1963) and they prepared characteristic profiles for a variety of psychotropic drugs but not including any hallucinogens.

We have prepared BOVET and GATTI profiles for mescaline, LSD and dimethyltryptamine. These all show a characteristic and similar dose-dependent profile. This consists of a decrease of the efficient responses and increased of *both* the premature and delayed responses; together with increase of reaction time at a large dose, and a decrease of reaction time at a low dose.

A typical profile for mescaline is shown in Fig. 2A. This profile is different to the distinct profiles obtained by BOVET and GATTI (for chlorpromazine, amphetamine, amitriptyline and reserpine). None of

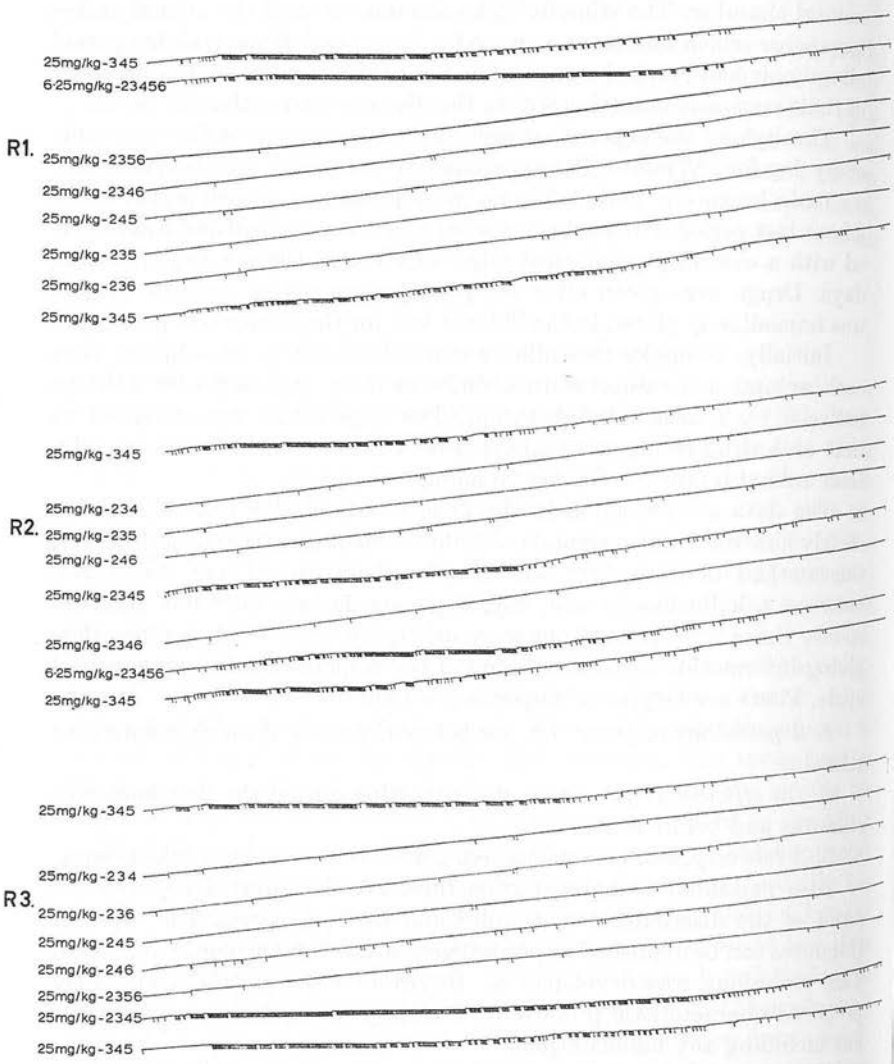

Fig. 1. Cumulative records showing the effects of position and number of methoxy group substitution on a discriminated continuous schedule

the drugs tested by Bovet and Gatti showed the "hallucinogenic" profile—shown by all 3 of the hallucinogens we have tested. (This analysis will be presented in more detail in a subsequent communication.) For our present purposes it is sufficient to note that this technique has been validated against 3 hallucinogens and 4 non-hallucinogens. Throughout the experiment all drugs were administered in 0.5 ml saline.

Results

In all cases no disruption of behaviour was detected during the saline control days nor the pre-injection period prior to drug administration. The results obtained with 25 mg/kg mescaline given to each animal before and after drug sequences (Fig. 1) indicate that any tolerance which had developed over the experimental days was negligible. In all these compounds it was felt that doses above 25 mg/kg might lead to toxic or non-specific effects or to direct action on the neuro-muscular junction, etc. So no doses larger than this were used.

1. All three mono-substituted compounds (ortho-, meta-, para-) were inactive in doses up to 25 mg/kg.

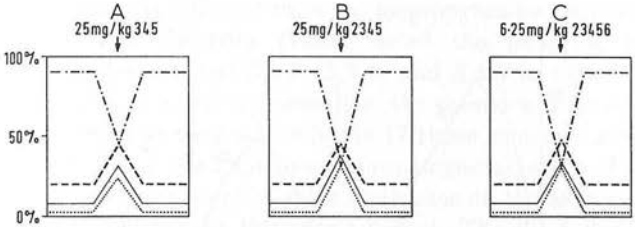

Fig. 2. Percentage analysis of Operant Responses and Reaction Time (Rat R 2). *A*—25 mg/kg 3,4,5-trimethoxy phenyl ethylamine (= mescaline). *B*—mg/kg 2,3,4,5-tetramethoxy phenylethylamine. *C*—6.25 mg/kg 2,3,4,5,6-pentamethoxy phenylethylamine. ——— Premature Responses; ——— Reaction Time; ·—·—· Efficient Responses; ····· Late Responses

2. The 3,4 compound has already been shown to be inactive. All the other di-substituted compounds were tested: (i.e. 2,3; 2,4; 2,5; 2,6; 3,5) on the Sidman technique and were inactive.

3. All possible tri-substituted compounds were tested (2,3,4[1]; 2,3,5; 2,3,6; 2,4,5; 2,4,6; 3,4,5). They proved inactive except the last (mescaline itself) (Fig. 2).

4. Of the three possible tetramethoxy compounds, the 2,3,4,5 was somewhat more active than mescaline whereas the other two (2,3,5,6; 2,4,5,6) were inactive. 12.5 mg/kg of the 2,3,4,5 compound produces an effect somewhat similar to 25 mg/kg mescaline.

5. The pentamethoxy compound (2,3,4,5,6) was by far the most active compound in this series we have yet tried. 3.125 mg/kg of this compound produced an effect approximately similar to 25 mg/kg mescaline.

Selected data for these compounds are depicted in Fig. 3 for the shuttle box schedule showing the biphasic curve obtained for the putative active

[1] This compound was reported as non-hallucinogenic in man by Slotta and Müller (1936): interestingly enough they claimed it was *more* active as a psychotomimetic agent in schizophrenics than mescaline. This observation would be of the greatest importance if it could be confirmed.

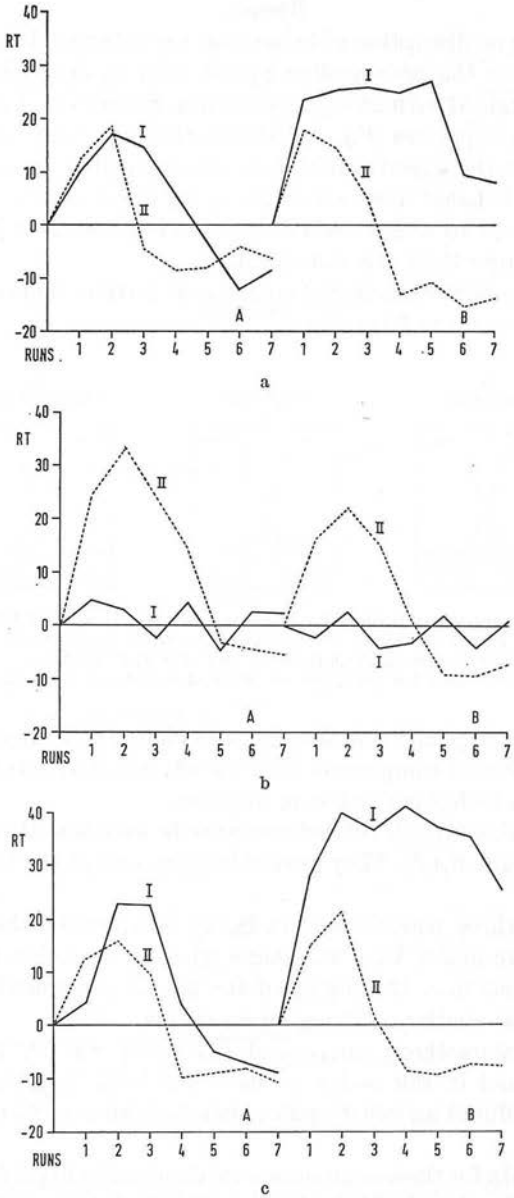

Fig. 3 a—c. Comparison of effects of mescaline and three analogues. Abscissa: Blocks of runs of 20 trials each. The interval between runs represents 13 min in each case (run 8 min, 5 min time out). Ordinate: Mean change in reaction time in seconds (D—$\bar{S}$). Each point represents 80 readings (20 trials ×4 animals) averaged. *I* —— a: 2,3,4,5 tetramethoxyphenylethylamine *A* 12.5 mg/kg, *B* 25 mg/kg; b: 2,3,5,6 tetramethoxyphenylethylamine A 12.5 mg/kg, B 25 mg/kg; c: 2,3,4,5,6 pentamethoxy phenylethylamine *A* 3.1 mg/kg, *B* 6.25 mg/kg. *II* ····· in each case is the averaged response to 25 mg/kg mescaline for the four animals involved

hallucinogens and in Fig. 1 showing the clear-cut index of activity provided by the Sidman schedule, and in Fig. 2 showing the Bovet-Gatti profiles for the active compounds.

Discussion

Our data provides evidence that the psychotomimetic properties of mescaline depend on the presence of all 3 methoxy groups and that the 3,4,5 configuration is necessary. The effect of adding extra methoxy groups, provided that the 3,4,5 configuration is maintained, is to increase activity as determined by our tests. One extra methoxy group produces a moderate increase in activity, two a marked increase.

The first point of interest is that the behaviour of the phenylethylamine derivatives is different from the isopropylamine derivatives in the following respect. SHULGIN (1964) tested the following trimethoxy amphetamine derivatives: 3,4,5; 2,3,4; and 2,4,5 in man. The former was about twice as active as mescaline, the second was inactive and the 2,4,5 compound was very active (some 17 times as active as mescaline); whereas we find that the 2,4,5 mescaline analogue is inactive. To check this point we tested these amphetamine analogues on the Sidman avoidance schedule. This confirmed SHULGIN's report. The 2,4,5 derivative was very active. Further data on the amphetamine series will be presented in a subsequent communication.

Data has been presented by CLARK *et al.*, (1965) on the relationship between methoxy group configuration and susceptibility to oxidation by mescaline oxidase. They found that all compounds in this series with *both* 2 and 6 positions substituted (2,6; 2,3,6; 2,4,6) *and* all compounds with more than 3 methoxy groups were not substrates for this enzyme[2].

Clearly, therefore, immunity to attack by monoamine oxidase is not a necessary nor sufficient condition for psychotomimetic activity. Although, if the molecule has already the necessary 3,4,5 methoxy group configuration, the addition of groups in the 2 and 6 positions may lead to increased activity due to the consequent blockade of this pathway of metabolism, by either of the two mechanisms outlined above.

Mescaline might operate by one or more of the following mechanisms:

1. Competitive inhibition of some enzyme reaction—for example, O-methyl transferase, in which case the structural specification we have determined may reflext the structural requirements at the receptor site. Mescaline and its active relatives might block the active sites of

[2] The enzyme was obtained from rabbit liver and will deaminate both mescaline and tyramine. The deamination of the former but not the latter is inhibited by 0.005 M semicarbazide. In this respect mescaline was unique as the deamination or failure of deamination of all the other compounds was not affected by semicarbazide, whereas with mescaline this was metabolized in the absence, but not the presence, of semicarbazide.

O-methylation leading to profound upsets in neurone biochemistry. The increase in activity with increased methoxylation may give a clue as to the mechanisms operating here.

2. Since mescaline can be demethylated in the body perhaps it can operate as a methyl donor thus linking its effect to that of methionine (which makes schizophrenic symptoms worse in certain cases; POLLIN *et al.*, 1961). In which case increasing methoxylation might increase this effect. This hypothesis lends itself readily to biochemical testing.

3. It has frequently been suggested that mescaline may exert its psychological effects by means of some indolic derivative. Our data make this improbable since ring closure in the pentamethoxy compound is precluded.

4. Mescaline might operate by blocking a transport mechanism for some close relative such as dopamine. The three bulky methoxy groups placed symmetrically at the end of the benzene opposite the site of attachment of the C—C—N chain common to mescaline and dopamine might impede transport across some membrane by a purely mechanical effect.

The increasing effect of progressive methoxylation might fit in with this hypothesis but it is hard to see why the other two tetra compounds would be inactive.

Clearly, before we can settle this problem, it would be necessary to conduct a close study of these methoxylated compounds to determine a variety of their biochemical and pharmacological properties to see which are shared by, and only by, the active as opposed to the inactive compounds. The effects of these compounds need also to be validated by human test—particularly the three tetramethoxy and the pentamethoxy compounds.

The compounds tested were synthesized by three of us. The details are fully reported elsewhere (BENINGTON *et al.*, 1954, 1955, 1958).

Summary

Two behavioural indices for psychotomimetic activity have been used to elucidate the probable role of methoxy group configuration in the mescaline molecule. The first method using a shuttle box CAR has been reported previously in this series. The second is based on the Sidman Avoidance schedule and utilizes the Bovet-Gatti profiles. Our results indicate that only two analogues of mescaline are active—the 2,3,4,5 and 2,3,4,5,6 compounds. This indicates that the 3,4,5 configuration is necessary and that adding extra methoxy groups increases activity. The great activity of the penta methoxy compound may be due to the fact that this compound substituted in the 2 and 6 positions cannot be metabolized by mescaline oxidase. The significance of these results is discussed.

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APPENDIX 2

COMPUTER PROGRAMS AND OUTPUT DATA

```
***A
JOB
MRC 001/00001010/  THREE.  R.J.BRADLEY
OUTPUT
0 LINE PRINTER 1000 LINES
EXECUTION 3 MINUTES
COMPILER AA

begin
integer array v(1:6),z(0:6,1:6),x(0:6,0:6,1:6)
integer f,i,j,k,dog,hen,cat,total,n
real e
cycle i=1,1,6
v(i)=0
cycle j=1,1,6
z(i,j)=0
cycle k=1,1,6
x(i,j,k)=0
repeat
repeat
repeat
dog=0
hen=0
total=0
1: read (e)
-> 2 if e=-3
total=total +1
f= intpt(e*0.02) +1
if f>6thenf=6
v(f)=v(f) +1
z(hen,f)=z(hen,f) +1
x(dog,hen,f)=x(dog,hen,f) +1
dog=hen
hen=f
->1
2: newlines (4)
caption frequency ≠ and ≠ percentage  ≠ of ≠ responses ≠ in ≠ each
≠ of ≠ the ≠ 6 ≠ groups
newline
caption responses ≠ up ≠ to ≠ 5 ≠ seconds ≠ belong ≠ to ≠ group ≠
1 ≠ and ≠ so ≠ on
newline
e=0
cycle i=1,1,6
e=e + v(i)
repeat
-> 5 if e<0
```

```
e=100/e
5: cycle i=1,1,6
newline
print(i,3,0)
spaces (4)
print(v(i),6,0)
spaces (4)
print(v(i)*e,2,4)
repeat
newlines (2)
print(total,10,0)
newlines (2)
caption IRTs ≠ per ≠ OP
newline
cycle n=1,1,6
newline
e=0
cycle i=n,1,6
e=e+v(i)
repeat
->3ife<0
e=1/e
3: print (n,3,0)
spaces (4)
print (v(n)*e,1,4)
repeat
newlines (2)
caption frequencies ≠ of ≠ overlapping ≠ binary ≠ combinations
newline
caption the ≠ first ≠ number ≠ of ≠ a ≠ pair ≠ is ≠ given ≠ by ≠
the ≠ row ≠ number
newline
caption the ≠ second ≠ is ≠ given ≠ by ≠ the ≠ column ≠ number
newlines (2)
spaces (10)
cycle i=1,1,6
print (i,4,0)
repeat
newline
cycle i=1,1,6
newline
spaces (5)
print (i,1,0)
spaces (3)
cycle j=1,1,6
print (z(i,j),4,0)
repeat
repeat
```

```
newlines (2)
caption 2nd ś order ś IRTs ś per ś OP
newlines (2)
spaces (10)
cycle i=1,1,6
print (i,4,0)
repeat
newline
cycle i=1,1,6
newline
spaces (5)
print (i,1,0)
spaces (3)
cycle n=1,1,6
e=0
cycle j=n,1,6
e=e+z(i,j)
repeat
-> 7 if e<0
e=1/e
7: print (z(i,n)*e,1,2)
repeat
repeat
newlines (2)
caption frequencies ś in ś the ś binary ś matrix ś expressed ś as
ś probabilities ś
newline
caption  of ś the ś row ś totals
newlines (2)
spaces (10)
cycle i=1,1,6
print (i,4,0)
repeat
newline
cycle i=1,1,6
newline
spaces (5)
print (i,1,0)
spaces (3)
e=0
cycle j=1,1,6
e=e+ z(i,j)
repeat
-> 6 if e<0
e=1/e
6: cycle j=1,1,6
print (z(i,j)*e,1,2)
repeat
```

```
repeat
newlines (2)
caption frequencies ś of ś overlapping ś triads
newlines (2)
cycle i=1,1,6
newlines (2)
caption the ś first ś number ś of ś the ś triad ś is
print (i,2,0)
newline
spaces (10)
cycle j=1,1,6
print (j,4,0)
repeat
newline
cycle j=1,1,6
newline
spaces (5)
print (j,1,0)
spaces (3)
cycle k=1,1,6
print (x(i,j,k),4,0)
repeat
repeat
repeat
newlines (2)
caption transition ś probabilities ś of ś triads
newlines (4)
cycle i=1,1,6
newlines (2)
caption  the ś first ś number ś of ś the ś triad ś is
print (i,2,0)
newline
spaces (10)
cycle j=1,1,6
print (j,4,0)
repeat
newline
cycle j=1,1,6
newline
spaces (5)
print (j,1,0)
spaces (3)
e=0
cycle k=1,1,6
e=e +x(i,j,k)
repeat
-> 10 if e< 0
e=1/e
```

```
10: cycle k=1,1,6
print (x(i,j,k)*e,1,2)
repeat
repeat
repeat
end of program
```

```
17/07/67   13.16.08
EDINBURGH UNIVERSITY ATLAS AUTOCODE   05/06/67

MRC 001/00001010/  THREE.  R.J.BRADLEY
     0   BEGIN
   184   END OF PROGRAM

PROGRAM (+PERM) OCCUPIES 2884 ( 2433) WORDS
PROGRAM DUMPED
COMPILING TIME   20 SEC /  15 SEC
```

FREQUENCY AND PERCENTAGE OF RESPONSES IN EACH OF THE 6 GROUPS
RESPONSES UP TO 5 SECONDS BELONG TO GROUP 1 AND SO ON

1	291	4.0557
2	146	2.0348
3	3426	47.7491
4	2697	37.5889
5	389	5.4216
6	226	3.1498
	7175	

IRTs per OP

1	0.0406
2	0.0212
3	0.5085
4	0.8143
5	0.6325
6	1.0000

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS
THE FIRST NUMBER OF A PAIR IS GIVEN BY THE ROW NUMBER
THE SECOND IS GIVEN BY THE COLUMN NUMBER

	1	2	3	4	5	6
1	8	8	133	121	16	5
2	3	17	72	37	8	9
3	208	88	1635	1234	187	74
4	28	16	1371	1085	104	93
5	35	11	130	144	46	22
6	9	6	84	76	28	23

2ND ORDER IRTs per OP

	1	2	3	4	5	6
1	0.03	0.03	0.48	0.85	0.76	1.00
2	0.02	0.12	0.57	0.69	0.47	1.00
3	0.06	0.03	0.52	0.83	0.72	1.00
4	0.01	0.01	0.52	0.85	0.53	1.00
5	0.09	0.03	0.38	0.68	0.68	1.00
6	0.04	0.03	0.40	0.60	0.55	1.00

FREQUENCIES IN THE BINARY MATRIX EXPRESSED AS PROBABILITIES
OF THE ROW TOTALS

	1	2	3	4	5	6
1	0.03	0.03	0.46	0.42	0.05	0.02
2	0.02	0.12	0.49	0.25	0.05	0.06
3	0.06	0.03	0.48	0.36	0.05	0.02
4	0.01	0.01	0.51	0.40	0.04	0.03
5	0.09	0.03	0.34	0.37	0.12	0.06
6	0.04	0.03	0.37	0.34	0.12	0.10

FREQUENCIES OF OVERLAPPING TRIADS

THE FIRST NUMBER OF THE TRIAD IS 1

	1	2	3	4	5	6
1	0	0	4	3	1	0
2	0	0	6	2	0	0
3	8	5	57	57	4	2
4	3	0	56	54	6	2
5	2	0	5	7	0	2
6	0	0	5	0	0	0

THE FIRST NUMBER OF THE TRIAD IS 2

	1	2	3	4	5	6
1	0	0	2	1	0	0
2	0	2	5	10	0	0
3	2	1	39	25	3	2
4	0	0	20	13	3	1
5	0	1	2	3	1	1
6	0	0	5	3	1	0

THE FIRST NUMBER OF THE TRIAD IS 3

	1	2	3	4	5	6
1	6	6	97	86	13	0
2	3	11	48	21	4	1
3	82	49	802	581	90	31
4	6	4	652	493	37	42
5	24	3	64	70	21	5
6	3	2	29	25	9	6

THE FIRST NUMBER OF THE TRIAD IS 4

	1	2	3	4	5	6
1	0	1	15	11	0	1
2	0	0	11	2	1	2
3	112	31	633	500	66	29
4	19	6	540	442	44	34
5	5	3	33	42	16	5
6	4	2	35	32	10	10

THE FIRST NUMBER OF THE TRIAD IS 5

	1	2	3	4	5	6
1	2	1	13	16	2	1
2	0	2	2	2	2	3
3	2	1	66	43	11	7
4	0	3	70	53	9	9
5	4	2	14	15	5	6
6	1	1	4	9	3	4

THE FIRST NUMBER OF THE TRIAD IS 6

	1	2	3	4	5	6
1	0	0	2	4	0	3
2	0	2	0	0	1	3
3	2	1	37	28	13	3
4	0	3	33	30	5	5
5	0	2	12	7	3	3
6	1	1	6	7	5	3

TRANSITION PROBABILITIES OF TRIADS

THE FIRST NUMBER OF THE TRIAD IS 1

	1	2	3	4	5	6
1	0.00	0.00	0.50	0.38	0.12	0.00
2	0.00	0.00	0.75	0.25	0.00	0.00
3	0.06	0.04	0.43	0.43	0.03	0.02
4	0.02	0.00	0.46	0.45	0.05	0.02
5	0.12	0.00	0.31	0.44	0.00	0.12
6	0.00	0.00	1.00	0.00	0.00	0.00

THE FIRST NUMBER OF THE TRIAD IS 2

	1	2	3	4	5	6
1	0.00	0.00	0.67	0.33	0.00	0.00
2	0.00	0.12	0.29	0.59	0.00	0.00
3	0.03	0.01	0.54	0.35	0.04	0.03
4	0.00	0.00	0.54	0.35	0.08	0.03
5	0.00	0.12	0.25	0.38	0.12	0.12
6	0.00	0.00	0.56	0.33	0.11	0.00

THE FIRST NUMBER OF THE TRIAD IS 3

	1	2	3	4	5	6
1	0.03	0.03	0.47	0.41	0.06	0.00
2	0.03	0.12	0.55	0.24	0.05	0.01
3	0.05	0.03	0.49	0.36	0.06	0.02
4	0.00	0.00	0.53	0.40	0.03	0.03
5	0.13	0.02	0.34	0.37	0.11	0.03
6	0.04	0.03	0.39	0.34	0.12	0.08

THE FIRST NUMBER OF THE TRIAD IS 4

	1	2	3	4	5	6
1	0.00	0.04	0.54	0.39	0.00	0.04
2	0.00	0.00	0.69	0.12	0.06	0.12
3	0.08	0.02	0.46	0.36	0.05	0.02
4	0.02	0.01	0.50	0.41	0.04	0.03
5	0.05	0.03	0.32	0.40	0.15	0.05
6	0.04	0.02	0.38	0.34	0.11	0.11

THE FIRST NUMBER OF THE TRIAD IS 5

	1	2	3	4	5	6
1	0.06	0.03	0.37	0.46	0.06	0.03
2	0.00	0.18	0.18	0.18	0.18	0.27
3	0.02	0.01	0.51	0.33	0.08	0.05
4	0.00	0.02	0.49	0.37	0.06	0.06
5	0.09	0.04	0.30	0.33	0.11	0.13
6	0.05	0.05	0.18	0.41	0.14	0.18

```
THE FIRST NUMBER OF THE TRIAD IS  6
          1    2    3    4    5    6

     1  0.00 0.00 0.22 0.44 0.00 0.33
     2  0.00 0.33 0.00 0.00 0.17 0.50
     3  0.02 0.01 0.44 0.33 0.15 0.04
     4  0.00 0.04 0.43 0.39 0.07 0.07
     5  0.00 0.07 0.44 0.26 0.11 0.11
     6  0.04 0.04 0.26 0.30 0.22 0.13
```

```
STOPPED AT LINE  184
MRC 001/00001010/  THREE.  R.J.BRADLEY
RUNNING TIME   2 MIN  51 SEC /  48 SEC
ELAPSED TIME3 MIN  25 SEC   COST 7 UNITS
```

```
***A
JOB
MRC 001/00001007/ PROBE INFORMATIC 6 BY 4TH R.J.BRADLEY
OUTPUT
0 LINE PRINTER 2000 LINES
EXECUTION 5 MINUTES
COMPILER AA


begin
integer array x(0:6,0:6,0:6,1:6), y(0:6,0:6,1:6), z(0:6,1:6), v(1:6)
integer f,i,j,k,l,sow,pig,dog,hen,cat,total
real  a,b,c,d,e,g
cycle i=1,1,6
v(i)=0
cycle j=1,1,6
z(i,j)=0
cycle k=1,1,6
y(i,j,k)=0
cycle l=1,1,6
x(i,j,k,l)=0
repeat
  repeat
    repeat
      repeat
dog=0
hen=0
cat=0
total=0
a=0
b=0
c=0
d=0
g= 1/log(2)
caption frequencies ≠ and ≠ conditional ≠ probabilities ≠ 6 ≠
categories
    newline
caption 5 ≠ steps ≠ in ≠ 5sec ≠ intervals ≠≠≠≠ 6th ≠ category ≠ is
≠ a ≠ dump
1: read (e)
-> 2 if e= -3
total = total +1
f = intpt(e*0.02) +1
if f>6 then f=6
v(f)=v(f) +1
z(cat,f)=z(cat,f) +1
y(hen,cat,f)=y(hen,cat,f) +1
x(dog,hen,cat,f)=x(dog,hen,cat,f) +1
```

```
dog=hen
hen=cat
cat=f
-> 1
2: cycle i=1,1,6
-> 8 if v(i)=0
newline
print (i,1,0)
spaces (2)
print (v(i),4,0)
spaces (2)
print (v(i)/total,0,4)
a=a-v(i)/total*log(v(i)/total)/g
cycle j=1,1,6
-> 7 if z(i,j)=0
newline
spaces (30)
print (i,1,0)
print (j,1,0)
spaces (2)
print (z(i,j),4,0)
spaces (2)
print (z(i,j)/v(i),0,4)
b=b-z(i,j)/(total-1)*log(z(i,j)/(total-1))/g
3:cycle k=1,1,6
-> 6 if y(i,j,k)=0
newline
spaces (60)
print (i,1,0)
print (j,1,0)
print (k,1,0)
spaces (2)
print (y(i,j,k),4,0)
spaces (2)
print (y(i,j,k)/z(i,j), 0,4)
c=c-y(i,j,k)/(total-2)*log(y(i,j,k)/(total-2))/g
4:cycle l=1,1,6
-> 5 if x(i,j,k,l)=0
newline
spaces (90)
print (i,1,0)
print (j,1,0)
print (k,1,0)
print (l,1,0)
spaces (2)
print (x(i,j,k,l),4,0)
spaces (2)
print (x(i,j,k,l)/y(i,j,k),0,4)
```

```
d=d-x(i,j,k,l)/(total-3)*log(x(i,j,k,l)/(total-3))/g
5:repeat
6:  repeat
7:    repeat
8:      repeat
d=d-c
c=c-b
b=b-a
caption  the ≠ end
newlines (4)
caption averaged ≠ uncertainties
newlines (2)
caption 4th ≠ order
spaces (5)
print (d,1,8)
newlines (4)
caption 3rd ≠ order
spaces (5)
print (c,1,8)
newlines (4)
caption 2nd ≠ order
spaces (5)
print (b,1,8)
newlines (4)
caption 1st ≠ order
spaces (5)
print (a,1,8)
end of program
```

```
***A
JOB
MRC 001/00001001/ MESCALINE R.J. BRADLEY.
EXECUTION 2 MINUTES
COMPILER AA

begin
integer array x(-1:23,0:23),y(0:23)
integer f,i,j,n,set
real e,total
cycle i=0,1,23
y(i)=0
cycle j=0,1,23
x(i,j)=0
repeat
repeat
set= -1
total=0
1:read (e)
->2 if e= -3
f=intpt(e*0.1)
f=23 if f>23
y(f)=y(f) +1
x(set,f)=x(set,f) +1
set=f
total=total +1
->1
2:newlines (4)
caption frequency ś and ś percentage ś of ś responses ś in ś each ś
of ś the ś twenty-four ś groups
newline
caption (responses ś 0 ś to ś 9 ś belong ś to ś group ś 0, ś 10 ś
to ś 19 ś to ś group ś 1, ś and ś so ś on)
newline
e=0
cycle i=0,1,23
e=e+y(i)
repeat
->5 if e<0
e=100/e
5:cycle i=0,1,23
newline
print (i,3,0)
spaces (4)
print (y(i),6,0)
spaces (4)
print (y(i)*e,2,4)
```

```
repeat
newlines (2)
print (total,8,0)
newlines (4)
caption IRTs ś per ś OP
newline
cycle n=0,1,23
newline
e=0
cycle i=n,1,23
e=e+y(i)
repeat
->3 if e<0
e=1/e
3: print (n,3,0)
spaces (4)
print (y(n)*e,1,4)
repeat
newlines (4)
caption frequencies ś of ś overlapping ś binary ś combinations
newline
caption the ś first ś number ś of ś a ś pair ś is ś given ś by ś
the ś row ś number, ś the ś c second ś is ś given ś by ś the ś
column ś number.
newline
caption rows ś are ś not ś numbered, ś columns ś are ś numbered.
newlines (2)
cycle i=0,1,23
print (i,4,0)
repeat
newline
cycle i=0,1,23
newline
cycle j=0,1,23
print (x(i,j),4,0)
repeat
repeat
newlines (4)
caption 2nd ś order ś IRTs ś per ś OP
newlines (2)
cycle i=0,1,23
print (i,4,0)
repeat
newline
cycle i=0,1,23
newline
cycle n=0,1,23
e=0
```

```
cycle j=n,1,23
e=e +x(i,j)
repeat
->7 if e<0
e=1/e
7:  print(x(i,n)*e,1,2)
repeat
repeat
newlines (4)
caption Frequencies ś in ś the ś binary ś matrix ś expressed ś as
ś probabilities ś c of ś the ś row ś totals
newlines (2)
cycle i=0,1,23
print (i,3,0)
space
repeat
newline
cycle i=0,1,23
newline
e=0
cycle j=0,1,23
e=e+x(i,j)
repeat
->6 if e<0
e=1/e
6:cycle j=0,1,23
print (x(i,j)*e,1,2)
repeat
repeat
newlines (4)
caption Frequencies ś in ś the ś binary ś matrix ś expressed ś as
ś probabilities ś c of ś the ś column ś totals
newlines (2)
cycle i=0,1,23
print (i,3,0)
space
repeat
newline
cycle i=0,1,23
newline
cycle j=0,1,23
e=0
cycle n=0,1,23
e=e +x(n,j)
repeat
-> 9 if e<0
e=1/e
9: print (x(i,j)*e,1,2); repeat; repeat; end of program
```

FREQUENCY AND PERCENTAGE O ORDER

0	199	2.7735
1	69	0.9617
2	13	0.1812
3	7	0.0976
4	3	0.0418
5	9	0.1254
6	6	0.0836
7	17	0.2369
8	33	0.4599
9	81	1.1289
10	200	2.7875
11	318	4.4321
12	576	8.0279
13	955	13.3101
14	1377	19.1916
15	1186	16.5296
16	654	9.1150
17	416	5.7979
18	271	3.7770
19	170	2.3693
20	121	1.6864
21	94	1.3101
22	72	1.0035
23	328	4.5714

7175 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2	1	1	0	0	1	0	0	2	3	5	7	18	26	34	37	29	7	9	2	5	4	1	5
1	1	0	1	0	0	0	0	0	1	2	5	6	7	11	12	2	10	3	2	2	0	1	2
0	0	0	0	0	0	0	0	1	0	0	1	2	2	2	3	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	1	1	0	0	1	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	2	1	0	1	1	1	0	2	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	1
0	0	0	0	0	2	0	0	3	1	0	0	1	3	2	0	0	0	0	2	0	1	0	2
1	0	0	0	0	0	0	0	0	2	2	3	5	3	4	2	1	1	1	1	1	0	0	6
2	0	0	0	0	0	0	1	2	3	8	7	6	12	8	11	7	6	3	0	1	1	0	3
2	0	0	1	0	0	1	2	1	3	17	14	28	23	27	22	21	13	6	3	4	3	1	8
4	1	0	0	1	0	1	3	2	11	22	28	39	47	40	37	17	21	17	9	2	5	2	9
14	3	0	0	1	1	0	2	2	10	31	37	64	67	95	63	42	34	33	21	8	7	10	31
32	12	3	1	0	1	2	0	4	15	40	63	96	151	112	116	89	78	45	33	19	11	9	23
91	29	8	4	1	0	0	4	8	15	29	66	133	174	192	194	143	92	57	28	25	27	12	45
18	5	0	0	0	2	1	0	0	5	12	16	55	171	383	282	102	44	19	16	10	3	6	36
3	0	0	0	0	0	0	0	1	0	5	12	32	82	192	175	63	24	14	6	5	4	5	31
1	0	0	0	0	0	1	1	0	1	3	10	19	59	115	86	50	13	9	11	6	4	7	20
0	0	0	0	0	0	0	0	1	2	2	9	12	38	64	48	22	15	14	6	5	1	4	28
1	0	0	0	0	0	0	0	1	0	2	2	10	29	37	29	12	9	9	7	2	4	2	14
10	3	0	0	0	0	0	1	1	0	0	6	7	18	10	15	6	14	6	3	6	3	2	9
4	2	0	0	0	0	0	2	1	2	4	6	7	7	11	10	8	8	7	2	6	0	2	5
5	1	0	0	0	0	0	0	0	0	2	2	2	8	7	5	12	5	3	5	2	2	2	9
8	11	0	0	0	2	0	1	3	4	12	23	31	23	28	39	24	20	16	12	11	14	6	40

FREQUENCY AND PERCENTAGE O ORDER

0	175	8.7151
1	34	1.6932
2	6	0.2988
3	4	0.1992
4	2	0.0996
5	4	0.1992
6	3	0.1494
7	5	0.2490
8	5	0.2490
9	17	0.8466
10	35	1.7430
11	79	3.9343
12	163	8.1175
13	296	14.7410
14	375	18.6753
15	308	15.3386
16	204	10.1594
17	121	6.0259
18	75	3.7351
19	32	1.5936
20	17	0.8466
21	5	0.2490
22	7	0.3486
23	36	1.7928

2008 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
15	7	3	0	0	1	0	0	0	3	6	10	10	31	23	21	19	13	7	2	0	1	1	2
1	0	0	1	0	0	0	0	0	2	1	2	5	6	6	4	2	2	1	1	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1	0	0	3	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0
3	0	0	0	0	0	1	0	0	0	0	2	2	1	3	2	0	1	0	2	0	0	0	0
2	0	0	1	0	0	0	0	0	0	3	4	7	5	5	4	1	1	1	0	1	0	0	0
11	1	0	0	0	1	0	1	0	2	4	4	12	13	10	7	2	2	4	0	2	0	1	2
21	5	1	1	2	0	0	0	0	1	1	12	23	23	20	21	13	7	7	2	1	0	0	2
43	9	0	0	0	2	0	0	2	4	7	15	28	32	57	36	27	17	5	2	3	2	1	4
60	10	1	1	0	0	1	0	0	4	7	13	31	52	60	44	33	22	12	8	5	0	2	9
5	0	0	0	0	0	0	1	0	1	2	5	18	62	75	59	44	19	6	4	2	1	0	4
2	0	0	0	0	0	1	0	0	0	1	3	8	24	61	49	26	9	13	1	0	0	2	4
1	0	0	0	0	0	0	0	0	0	0	3	4	20	31	20	14	8	12	4	1	0	0	3
0	0	0	0	0	0	0	0	0	0	0	1	2	9	11	23	10	7	3	4	0	1	0	4
0	1	0	0	0	0	0	0	0	0	0	0	0	6	5	8	3	5	1	1	2	0	0	0
4	0	0	0	0	0	0	0	0	0	1	0	2	2	1	2	3	1	0	1	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	2	1	0	0	0	0	0	0
2	1	1	0	0	0	0	0	1	0	1	4	4	5	4	4	1	4	2	0	0	0	0	2

FREQUENCY AND PERCENTAGE 0 ORDER

0	134	3.6642
1	29	0.7930
2	11	0.3008
3	10	0.2734
4	11	0.3008
5	17	0.4649
6	32	0.8750
7	37	1.0118
8	57	1.5587
9	97	2.6524
10	160	4.3752
11	271	7.4104
12	422	11.5395
13	575	15.7233
14	715	19.5515
15	526	14.3834
16	249	6.8089
17	103	2.8165
18	69	1.8868
19	35	0.9571
20	19	0.5196
21	22	0.6016
22	10	0.2734
23	46	1.2579

3657 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
11	2	0	0	0	1	1	2	3	3	10	13	16	24	22	12	5	4	1	2	0	0	1	1
0	0	0	1	1	0	0	0	1	3	6	2	5	1	5	1	0	1	0	0	1	0	0	1
0	0	0	0	0	0	0	1	0	0	0	3	0	2	1	1	1	0	1	1	0	0	0	0
1	0	0	0	0	0	0	0	1	0	0	3	1	0	1	1	1	0	1	0	0	0	0	0
0	0	0	0	0	0	0	1	0	1	0	3	3	0	0	1	1	1	0	0	0	0	0	0
1	0	0	0	0	0	1	1	0	1	3	0	4	2	2	1	1	0	0	0	0	0	0	0
1	0	0	0	0	0	3	2	2	1	6	8	2	4	0	2	0	0	1	0	0	0	0	0
0	0	0	0	0	1	2	1	2	5	5	6	5	3	1	1	2	0	1	1	0	0	0	1
1	0	0	0	0	3	4	1	3	3	8	10	5	4	4	5	1	1	1	2	0	0	0	1
0	0	1	1	1	0	2	1	5	7	10	7	15	16	15	8	4	0	0	0	2	1	1	0
4	1	0	1	4	1	4	3	5	9	17	18	25	21	19	13	6	5	1	1	1	0	1	0
10	1	1	3	0	2	4	5	6	11	12	31	44	39	46	19	16	9	3	4	3	0	0	2
17	2	3	1	2	3	1	5	5	11	20	42	69	73	56	42	24	19	13	2	1	5	2	3
27	8	5	0	1	1	3	4	9	18	31	51	78	88	76	65	52	17	14	8	4	4	0	11
51	11	1	2	2	3	4	8	13	18	26	50	99	111	107	84	43	28	21	10	3	8	1	11
5	2	0	0	0	2	2	1	1	3	3	10	26	100	189	129	34	5	3	0	2	1	0	8
1	0	0	0	0	0	0	0	0	1	0	4	7	37	88	78	25	4	1	1	0	0	1	1
0	0	0	0	0	0	0	0	0	0	1	1	5	19	39	28	8	1	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0	1	1	4	10	28	9	11	2	1	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	0	3	6	8	10	2	2	0	0	0	0	2	2
1	0	0	1	0	0	0	0	0	0	0	2	0	5	1	3	1	2	2	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0	1	2	2	2	2	5	1	0	1	2	1	1	0	1
0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1	2	1	0	1	0	1	0	1
2	2	0	0	0	0	0	0	1	2	0	4	3	8	4	7	7	1	3	0	0	0	0	2

FREQUENCY AND PERCENTAGE 0 ORDER

0	304	10.2772
1	27	0.9128
2	7	0.2366
3	2	0.0676
4	2	0.0676
5	8	0.2705
6	2	0.0676
7	12	0.4057
8	21	0.7099
9	40	1.3523
10	76	2.5693
11	131	4.4287
12	230	7.7755
13	407	13.7593
14	544	18.3908
15	465	15.7201
16	277	9.3644
17	132	4.4625
18	67	2.2650
19	43	1.4537
20	31	1.0480
21	24	0.8114
22	16	0.5409
23	90	3.0426

2958 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
60	2	1	0	0	3	0	0	7	4	7	12	23	41	52	28	26	13	9	5	2	0	1	8
3	0	0	0	0	0	0	0	0	1	2	1	2	7	4	2	0	1	0	1	0	1	0	2
2	0	0	0	0	1	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
1	2	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	0	1	1	1	1	0	1	0	1	3	0	0	0	0	0
0	1	0	0	0	0	0	0	0	1	2	1	2	4	4	1	3	0	1	0	0	0	1	0
4	1	0	0	0	0	0	1	2	2	3	6	3	5	4	2	0	2	1	1	1	1	0	1
5	0	0	0	0	0	0	1	0	5	6	9	5	6	7	13	7	4	2	2	0	1	1	2
9	1	2	0	0	2	0	1	1	4	8	14	19	17	7	16	13	7	1	3	3	1	1	1
31	1	0	0	1	0	1	2	4	4	9	15	28	39	26	27	15	8	1	0	1	6	3	7
60	4	0	0	0	0	0	1	1	6	10	28	51	57	62	36	38	21	6	3	6	2	1	14
113	11	2	2	1	1	1	3	0	6	14	21	37	68	88	37	44	30	14	15	12	3	3	18
1	1	0	0	0	0	0	1	2	3	6	5	18	77	144	131	46	9	9	2	0	4	0	6
0	0	1	0	0	0	0	0	0	0	1	6	10	47	66	87	44	5	6	1	0	0	0	3
0	0	0	0	0	0	0	1	0	0	1	0	3	14	43	42	15	12	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	1	2	2	5	4	16	21	8	5	2	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	0	4	2	12	10	7	3	3	0	1	0	0	1
2	0	0	0	0	0	0	0	0	0	1	0	3	3	3	3	3	4	2	2	2	0	0	3
4	1	0	0	0	0	0	0	0	0	2	0	2	2	1	1	3	0	1	2	0	3	0	2
1	0	1	0	0	0	0	0	0	0	0	2	2	2	3	0	0	0	1	1	1	0	0	2
4	2	0	0	0	0	0	0	3	2	1	7	8	9	2	7	4	6	4	4	1	2	4	20

FREQUENCY AND PERCENTAGE 0 ORDER

0	108	4.7368
1	11	0.4825
2	1	0.0439
3	0	0.0000
4	2	0.0877
5	3	0.1316
6	4	0.1754
7	5	0.2193
8	20	0.8772
9	39	1.7105
10	68	2.9825
11	121	5.3070
12	228	10.0000
13	357	15.6579
14	406	17.8070
15	297	13.0263
16	175	7.6754
17	124	5.4386
18	85	3.7281
19	52	2.2807
20	27	1.1842
21	43	1.8860
22	16	0.7018
23	88	3.8596

2280 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
9	2	1	0	0	0	1	0	0	1	4	9	8	14	7	11	16	6	5	4	2	1	1	6
1	0	0	0	0	0	0	0	1	0	0	2	0	4	0	0	1	2	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	4	2	2	3	1	4	2	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	1	2	2	4	7	5	6	6	1	3	1	0	0	0	0	1
3	0	0	0	0	0	0	1	3	3	4	6	12	6	6	7	8	1	3	0	1	1	1	2
8	1	0	0	0	0	0	1	2	4	7	10	9	21	17	13	10	8	4	0	1	2	2	1
9	4	0	0	0	2	0	1	3	3	16	8	22	17	28	39	30	11	9	9	2	7	1	7
28	1	0	0	0	0	0	0	0	9	11	34	38	35	50	35	32	30	17	12	3	7	3	12
31	3	0	0	0	1	0	0	6	8	13	29	35	42	62	48	33	25	17	14	10	10	2	16
2	0	0	0	0	0	0	0	0	0	1	4	35	82	88	54	7	8	3	1	1	2	0	9
0	0	0	0	0	0	0	0	0	0	0	2	16	52	53	26	6	9	5	2	1	0	0	3
0	0	0	0	0	0	0	0	0	0	0	4	13	28	23	31	9	3	7	3	0	1	0	2
0	0	0	0	0	0	0	0	0	0	1	1	11	17	30	6	5	3	1	1	0	2	1	6
0	0	0	0	0	0	0	0	0	0	0	1	4	16	18	4	5	1	2	0	1	0	0	0
2	0	0	0	0	0	1	0	0	1	0	0	2	1	2	5	0	1	4	0	2	1	1	4
6	0	0	0	1	0	0	0	0	0	2	1	3	3	1	4	4	3	2	3	0	4	2	4
3	0	0	0	0	0	1	0	0	0	1	0	1	0	2	0	2	2	1	2	0	1	0	0
5	0	0	0	0	0	0	1	0	5	4	2	7	9	10	6	4	7	4	0	3	4	2	15

FREQUENCY AND PERCENTAGE O ORDER

0	324	12.5972
1	34	1.3219
2	10	0.3888
3	7	0.2722
4	3	0.1166
5	6	0.2333
6	11	0.4277
7	18	0.6998
8	37	1.4386
9	58	2.2551
10	97	3.7714
11	172	6.6874
12	216	8.3981
13	301	11.7030
14	368	14.3079
15	351	13.6470
16	245	9.5257
17	123	4.7823
18	79	3.0715
19	34	1.3219
20	18	0.6998
21	14	0.5443
22	9	0.3499
23	37	1.4386

2572 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
58	5	2	2	0	1	3	3	11	13	19	19	35	44	33	20	20	13	10	3	2	3	2	3
7	0	0	0	0	1	0	0	0	1	2	3	3	1	1	6	3	1	2	1	1	1	0	0
0	0	0	0	0	0	1	0	1	0	0	2	1	1	1	0	1	1	1	0	0	0	0	0
0	1	0	0	0	0	0	0	0	1	1	0	1	2	0	0	0	0	1	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	1	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	0	0	2	1	1	2	1	0	0	2	0	0	0	0	0
0	2	0	0	0	0	1	0	0	2	3	1	4	0	2	2	0	1	0	0	0	0	0	0
2	0	0	1	1	0	0	0	2	2	4	3	7	1	3	3	3	0	2	0	1	0	1	0
8	0	0	0	1	0	0	3	1	4	5	5	7	9	6	2	0	1	2	1	0	0	0	3
12	0	0	0	0	0	0	0	3	6	10	15	7	9	11	11	2	0	3	4	2	0	0	2
31	3	1	1	0	2	2	3	5	4	10	18	14	19	20	16	8	7	1	2	1	1	0	3
38	3	1	1	0	0	0	2	4	5	5	17	25	34	26	17	7	7	8	6	5	0	1	4
68	4	1	1	1	1	4	2	5	7	11	21	28	38	34	24	20	12	7	2	4	2	1	3
85	14	2	1	0	1	0	1	3	6	21	30	33	34	39	33	22	10	14	5	0	6	2	6
5	1	1	0	0	0	0	2	0	1	3	13	19	46	98	77	54	17	5	2	0	0	1	6
0	0	0	0	0	0	0	0	0	4	1	10	13	22	46	65	50	24	5	3	0	1	0	1
0	0	0	0	0	0	0	0	0	1	1	3	8	10	17	38	24	10	6	3	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	1	3	14	11	17	16	10	6	0	0	0	0	1
0	0	0	0	0	0	0	1	1	0	0	3	1	8	1	8	5	4	1	0	1	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	2	1	1	2	3	5	0	0	1	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	1	1	3	2	3	0	0	1	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	1	0	1	2	1	0	1	1	0	0	0	0	0
3	0	0	0	0	0	0	1	0	0	1	2	4	3	6	4	5	4	0	1	1	0	1	1

FREQUENCY AND PERCENTAGE O ORDER

0	80	3.5826
1	14	0.6270
2	11	0.4926
3	5	0.2239
4	8	0.3583
5	6	0.2687
6	10	0.4478
7	14	0.6270
8	21	0.9404
9	54	2.4183
10	73	3.2691
11	118	5.2844
12	156	6.9861
13	194	8.6879
14	214	9.5835
15	187	8.3744
16	171	7.6579
17	139	6.2248
18	107	4.7918
19	68	3.0452
20	45	2.0152
21	40	1.7913
22	34	1.5226
23	464	20.7792

2233 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
3	2	1	0	0	0	0	0	0	3	1	6	5	9	11	13	6	3	3	4	2	0	0	8
0	0	0	0	0	0	0	0	1	0	1	1	1	3	3	0	3	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	1	0	2	2	1	1	1	0	1	1	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	1	0	1	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	0	2	0	1	0	0	2	1	0	0	0	0	0	0
0	1	0	1	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	1	0	1	2	3	0	0	0	0	0	0	1	0	0	1
1	0	0	0	1	0	0	0	0	1	2	0	1	3	0	3	0	0	0	1	0	0	0	1
0	0	0	0	0	0	0	0	1	3	5	2	2	3	1	0	1	0	0	0	0	0	1	2
1	2	0	1	0	1	0	2	2	2	1	7	3	6	7	4	2	4	3	1	1	0	1	3
4	1	2	0	0	0	2	0	2	2	3	4	5	8	9	8	4	6	8	2	1	2	0	0
5	2	2	0	1	0	0	2	0	5	6	10	8	13	12	10	10	6	6	2	6	1	2	9
3	0	2	1	3	1	0	3	2	2	10	14	15	19	17	12	9	16	11	1	3	4	1	7
12	1	1	0	1	2	2	0	3	7	9	11	19	19	26	17	16	15	8	7	2	2	2	12
10	0	3	0	0	0	2	1	5	4	5	14	16	28	27	20	24	15	12	5	5	5	4	9
5	0	0	0	0	0	0	1	0	5	2	4	10	11	5	12	12	10	2	8	4	3	2	91
4	1	0	0	1	0	0	1	0	4	4	7	3	8	8	7	4	6	6	5	2	1	2	97
4	1	0	0	0	0	0	1	0	2	1	3	6	4	5	11	7	4	3	2	4	2	4	75
4	1	0	0	0	0	0	0	0	2	3	0	0	5	3	8	10	1	9	0	3	2	1	55
3	1	0	0	0	1	0	0	1	0	1	2	3	0	3	6	7	4	0	1	0	1	1	33
3	0	0	1	0	0	0	0	0	1	1	4	2	4	6	3	2	3	2	4	0	1	0	7
2	0	0	0	0	0	0	0	0	2	1	1	5	3	2	4	6	2	4	0	1	1	0	6
1	1	0	0	0	0	0	0	1	0	0	0	2	3	7	0	7	4	1	2	0	2	0	3
13	0	0	0	0	1	4	3	3	6	17	23	45	39	59	46	38	38	27	22	10	13	13	44

FREQUENCY AND PERCENTAGE O ORDER

0	59	3.4953
1	41	2.4289
2	5	0.2962
3	3	0.1777
4	1	0.0592
5	1	0.0592
6	2	0.1185
7	2	0.1185
8	3	0.1777
9	16	0.9479
10	47	2.7844
11	93	5.5095
12	165	9.7749
13	204	12.0853
14	369	21.8602
15	298	17.6540
16	149	8.8270
17	69	4.0877
18	56	3.3175
19	26	1.5403
20	17	1.0071
21	17	1.0071
22	9	0.5332
23	36	2.1327

1688 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
3	2	0	0	0	0	0	0	0	0	2	1	6	16	12	11	3	2	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	1	1	6	4	2	8	6	4	1	5	1	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	2	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	1	1	2	1	6	1	3	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	4	1	9	11	5	3	7	0	3	1	1	0	1	0	1
3	0	0	0	0	0	2	0	0	1	7	10	17	13	16	13	6	2	1	0	1	0	0	1
3	4	1	0	0	0	0	0	0	2	10	15	23	23	27	20	15	12	3	2	2	0	0	3
6	8	0	0	1	1	0	1	0	4	6	19	31	33	33	22	17	7	6	1	0	3	1	4
34	22	2	0	0	0	0	0	1	3	12	22	43	41	60	42	31	16	18	7	3	2	1	9
3	1	0	0	0	0	0	0	0	0	0	2	9	36	108	83	28	8	7	1	1	1	2	8
0	0	0	0	0	0	0	0	0	0	0	1	2	11	52	41	18	5	5	4	4	2	2	2
0	0	0	0	0	0	0	1	1	0	1	1	0	6	22	16	9	2	3	0	1	1	2	3
0	0	0	0	0	0	0	0	0	0	0	2	1	6	11	13	9	4	3	2	2	2	0	1
0	0	0	0	0	0	0	0	0	0	0	1	1	4	7	8	2	1	0	0	0	0	1	1
0	1	2	0	0	0	0	0	0	0	1	0	0	1	1	2	1	0	1	3	1	3	0	0
2	1	0	1	0	0	0	0	0	0	0	0	2	0	1	5	0	1	0	1	1	1	0	1
0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	3	1	1	0	1	0	0	0	0
4	2	0	1	0	0	0	0	0	0	2	2	4	3	2	6	3	2	3	1	0	0	0	0

FREQUENCY AND PERCENTAGE O ORDER

0	52	3.3269
1	16	1.0237
2	9	0.5758
3	19	1.2156
4	26	1.6635
5	52	3.3269
6	91	5.8221
7	139	8.8932
8	207	13.2438
9	202	12.9239
10	146	9.3410
11	122	7.8055
12	82	5.2463
13	47	3.0070
14	30	1.9194
15	26	1.6635
16	12	0.7678
17	8	0.5118
18	8	0.5118
19	3	0.1919
20	6	0.3839
21	7	0.4479
22	10	0.6398
23	243	15.5470

1563 IS THE TOTAL

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
4	0	2	0	0	2	8	5	5	6	6	4	6	0	4	0	0	0	0	0	0	0	0	0
1	0	0	1	1	0	0	2	2	5	0	3	0	0	1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	2	3	1	3	3	1	3	0	0	0	0	0	1	0	0	0	0	0	0
1	0	0	0	0	2	1	3	7	3	4	1	4	0	0	0	0	0	0	0	0	0	0	0
4	2	0	3	1	3	5	10	7	5	5	4	1	0	0	1	0	0	1	0	0	0	0	0
1	2	0	1	3	4	7	15	25	12	8	6	3	1	2	0	0	0	1	0	0	0	0	0
3	1	0	3	4	6	12	19	31	21	9	15	6	3	2	1	0	1	0	0	0	0	0	2
8	3	2	4	5	15	14	18	39	35	25	14	10	5	2	2	0	0	2	0	0	0	1	3
11	3	0	3	4	4	13	29	34	35	20	18	11	6	3	2	2	0	0	0	1	0	0	3
2	2	3	1	2	3	5	9	7	17	7	10	6	2	1	2	2	1	0	0	0	1	1	62
1	0	0	1	0	1	6	3	7	7	9	4	3	5	0	2	1	0	0	0	0	1	5	66
1	1	1	0	1	2	2	3	6	10	3	4	2	2	2	0	0	0	0	0	1	1	2	38
3	0	0	1	0	1	1	0	2	2	2	5	3	2	1	1	0	0	0	0	0	1	0	22
1	0	0	0	0	1	1	3	1	2	2	4	0	0	1	1	1	0	0	0	1	0	0	11
1	0	0	0	0	0	1	0	2	1	4	1	1	1	1	1	0	1	1	0	0	0	0	10
1	0	0	0	0	0	0	2	2	0	1	1	0	0	1	1	0	0	0	0	0	0	0	3
1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	2
0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	1	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	1	0	2	0	1	0	0	1	0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	2	0	0	1	1	1	1	0	3	0	0	0	0	0	0	0	0	0	1
5	2	1	1	4	3	11	15	24	35	31	20	23	15	9	11	5	3	2	3	3	3	0	13

```
***A
JOB
MRC 001/00001011/ HISTOSTAT RED   R.J.BRADLEY
OUTPUT
0 SEVEN-HOLE PUNCH 30 BLOCKS
EXECUTION 2 MINUTES
COMPILER AA

begin
integer array x(-1:23,0:23)
real array y(0:23)
integer f,i,j,n,set,k,m
real e,total
cycle i=0,1,23
y(i)=0
cycle j=0,1,23
x(i,j)=0
repeat
repeat
set= -1
total=0
k=0
m=0
1:read (e)
->2 if e= -3
f=intpt(e*0.1)
f=23 if f>23
y(f)=y(f) +1
x(set,f)=x(set,f) +1
set=f
total=total +1
->1
2: newlines (6)
spaces (10)
caption conditional ś probabilities
newlines (2)
cycle i=0,1,23
newlines (6)
spaces (10)
caption the ś first ś number ś of ś the ś binary ś combination ś
is ś
print (i,2,0)
newline
e=0
cycle j=0,1,23
e=e+x(i,j)
repeat
```

```
spaces (10)
if (y(i)*100/total)<4 then caption  this ś combination ś occupies
ś less ś than ś 4 ś percent
if (y(i)*100/total)<4 then -> 6
e=1/e
newlines (3)
spaces (4)
caption 0
spaces (8)
caption .1
spaces (8)
caption .2
spaces (8)
caption .3
spaces (8)
caption .4
spaces (8)
caption .5
newline
spaces (4)
cycle k=0,1,50
caption -
repeat
cycle j=0,1,23
m=0
newline
m= intpt(x(i,j)*e*100)-1
print (j,2,0)
space
caption |
-> 4 if m=-1
-> 3 if m=0
if 15<j<19 then punch binary (25)
cycle n=0,1,m
caption X
repeat
if 15<j<19 then punch binary (25)
3: caption |
4: repeat
6: repeat
newlines (6)
end of program
```

```
***A
 JOB
 MRC 001/00001001/ ISRT ANALYSIS R.J. BRADLEY.
 OUTPUT
 0 SEVEN-HOLE PUNCH 50 BLOCKS
 EXECUTION 2 MINUTES
 COMPILER AA

 begin
 integer array x(0:11,1:11),y(1:11)
 integer f,i,j,n,set
 real e,total,gag
 cycle i=1,1,11
 y(i)=0
 cycle j=1,1,11
 x(i,j)=0
 repeat
 repeat
 set= 0
 total=0
 gag=0
 1:read (e)
 ->2 if e= -3
 gag=gag+e
 ->1 unless 150<e<200
 f= intpt(gag*0.01)
 f=11 if f>11
 y(f)=y(f)+1
 x(set,f)=x(set,f)+1
 set=f
 total=total+1
 gag=0
 ->1
 2:newlines (4)
 caption frequency ≠ and ≠ percentage
 newline
 e=0
 cycle i=1,1,11
 e=e+y(i)
 repeat
 ->5 if e<0
 e=100/e
 5:cycle i=1,1,11
 newline
 print (i,3,0)
 spaces (4)
 print (y(i),6,0)
```

```
spaces (4)
print (y(i)*e,2,4)
repeat
newlines (2)
print (total,8,0)
newlines (4)
caption IRTs ß per ß OP
newline
cycle n=1,1,11
newline
e=0
cycle i=n,1,11
e=e+y(i)
repeat
->3 if e<0
e=1/e
3: print (n,3,0)
spaces (4)
print (y(n)*e,1,4)
repeat
newlines (4)
caption frequencies ß of ß overlapping ß binary ß combinations
newline
spaces (3)
cycle i=1,1,11
print (i,4,0)
repeat
newline
cycle i=1,1,11
newline
print (i,2,0)
space
cycle j=1,1,11
print (x(i,j),4,0)
repeat
repeat
```

ETC. as in Program MESCALINE

FREQUENCY AND PERCENTAGE OF RESPONSES IN EACH OF THE 11 GROUPS

1	1096	40.6377
2	194	7.1932
3	408	15.1279
4	323	11.9763
5	192	7.1190
6	115	4.2640
7	98	3.6337
8	65	2.4101
9	53	1.9651
10	34	1.2607
11	119	4.4123
	2697	

IRTs per OP

1	0.4064
2	0.1212
3	0.2900
4	0.3233
5	0.2840
6	0.2376
7	0.2656
8	0.2399
9	0.2573
10	0.2222
11	1.0000

FREQUENCIES IN THE BINARY MATRIX EXPRESSED AS PROBABILITIES OF THE ROW TOTALS

	1	2	3	4	5	6	7	8	9	10	11
1	0.42	0.07	0.16	0.12	0.07	0.05	0.03	0.02	0.01	0.01	0.04
2	0.39	0.06	0.20	0.08	0.07	0.03	0.07	0.01	0.03	0.02	0.05
3	0.43	0.07	0.15	0.10	0.06	0.05	0.04	0.01	0.02	0.01	0.06
4	0.41	0.08	0.15	0.13	0.07	0.03	0.03	0.04	0.02	0.02	0.02
5	0.40	0.10	0.15	0.11	0.07	0.03	0.03	0.04	0.02	0.02	0.03
6	0.38	0.06	0.15	0.09	0.10	0.07	0.04	0.03	0.03	0.01	0.03
7	0.32	0.07	0.13	0.21	0.07	0.04	0.03	0.04	0.02	0.01	0.05
8	0.45	0.05	0.09	0.11	0.05	0.08	0.03	0.05	0.03	0.00	0.08
9	0.36	0.08	0.11	0.17	0.06	0.04	0.02	0.00	0.06	0.00	0.11
10	0.44	0.12	0.09	0.09	0.15	0.00	0.00	0.03	0.03	0.00	0.06
11	0.34	0.07	0.12	0.18	0.09	0.03	0.05	0.03	0.01	0.02	0.08

FREQUENCIES IN THE BINARY MATRIX EXPRESSED AS PROBABILITIES OF THE COLUMN TOTALS

	1	2	3	4	5	6	7	8	9	10	11
1	0.42	0.38	0.42	0.41	0.39	0.47	0.36	0.37	0.28	0.44	0.35
2	0.07	0.06	0.09	0.05	0.07	0.04	0.14	0.03	0.11	0.09	0.08
3	0.16	0.15	0.15	0.12	0.14	0.17	0.16	0.08	0.15	0.09	0.20
4	0.12	0.14	0.12	0.13	0.11	0.08	0.10	0.18	0.15	0.15	0.07
5	0.07	0.10	0.07	0.07	0.07	0.04	0.06	0.11	0.06	0.12	0.05
6	0.04	0.04	0.04	0.03	0.06	0.07	0.05	0.06	0.08	0.03	0.03
7	0.03	0.04	0.03	0.06	0.04	0.03	0.03	0.06	0.04	0.03	0.04
8	0.03	0.02	0.01	0.02	0.02	0.04	0.02	0.05	0.04	0.00	0.04
9	0.02	0.02	0.01	0.03	0.02	0.02	0.01	0.00	0.06	0.00	0.05
10	0.01	0.02	0.01	0.01	0.03	0.00	0.00	0.02	0.02	0.00	0.02
11	0.04	0.04	0.03	0.07	0.06	0.03	0.06	0.05	0.02	0.06	0.08

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS
THE FIRST NUMBER OF A PAIR IS GIVEN BY THE ROW NUMBER,
THE SECOND IS GIVEN BY THE COLUMN NUMBER.

	1	2	3	4	5	6	7	8	9	10	11
1	457	74	171	134	75	54	35	24	15	15	42
2	75	12	38	16	14	5	14	2	6	3	9
3	177	29	62	39	26	19	16	5	8	3	24
4	132	27	49	42	21	9	10	12	8	5	8
5	77	19	29	22	14	5	6	7	3	4	6
6	44	7	17	10	12	8	5	4	4	1	3
7	31	7	13	20	7	4	3	4	2	1	5
8	29	3	6	7	3	5	2	3	2	0	5
9	19	4	6	9	3	2	1	0	3	0	6
10	15	4	3	3	5	0	0	1	1	0	2
11	40	8	14	21	11	4	6	3	1	2	9

2nd ORDER IRTs per OP

	1	2	3	4	5	6	7	8	9	10	11
1	0.42	0.12	0.30	0.34	0.29	0.29	0.27	0.25	0.21	0.26	1.00
2	0.39	0.10	0.36	0.23	0.26	0.13	0.41	0.10	0.33	0.25	1.00
3	0.43	0.13	0.31	0.28	0.26	0.25	0.29	0.12	0.23	0.11	1.00
4	0.41	0.14	0.30	0.37	0.29	0.17	0.23	0.36	0.38	0.38	1.00
5	0.40	0.17	0.30	0.33	0.31	0.16	0.23	0.35	0.23	0.40	1.00
6	0.38	0.10	0.27	0.21	0.32	0.32	0.29	0.33	0.50	0.25	1.00
7	0.32	0.11	0.22	0.43	0.27	0.21	0.20	0.33	0.25	0.17	1.00
8	0.45	0.08	0.18	0.26	0.15	0.29	0.17	0.30	0.29	0.00	1.00
9	0.36	0.12	0.20	0.38	0.20	0.17	0.10	0.00	0.33	0.00	1.00
10	0.44	0.21	0.20	0.25	0.56	0.00	0.00	0.25	0.33	0.00	1.00
11	0.34	0.10	0.20	0.37	0.31	0.16	0.29	0.20	0.08	0.18	1.00

FREQUENCY AND PERCENTAGE OF RESPONSES IN EACH OF THE 11 GROUPS

1	469	47.6626
2	43	4.3699
3	117	11.8902
4	104	10.5691
5	48	4.8780
6	44	4.4715
7	48	4.8780
8	27	2.7439
9	19	1.9309
10	12	1.2195
11	53	5.3862
	984	

IRTs per OP

1	0.4766
2	0.0835
3	0.2479
4	0.2930
5	0.1912
6	0.2167
7	0.3019
8	0.2432
9	0.2262
10	0.1846
11	1.0000

FREQUENCIES OF OVERLAPPING BINARY COMBINATIONS
THE FIRST NUMBER OF A PAIR IS GIVEN BY THE ROW NUMBER,
THE SECOND IS GIVEN BY THE COLUMN NUMBER.

	1	2	3	4	5	6	7	8	9	10	11
1	236	25	61	48	20	17	21	9	7	8	16
2	14	2	5	5	2	3	2	1	2	1	6
3	64	4	11	13	6	5	5	3	1	0	5
4	48	4	10	14	4	9	4	3	2	0	6
5	24	2	5	3	2	3	3	3	0	0	3
6	21	0	3	7	4	0	4	1	3	0	1
7	18	3	6	4	1	2	3	2	2	1	6
8	12	0	4	4	2	0	1	1	0	1	2
9	9	1	3	1	2	0	1	1	0	1	0
10	7	0	3	0	0	1	1	0	0	0	0
11	16	2	6	5	5	3	3	3	2	0	8

2nd order IRTs per OP

	1	2	3	4	5	6	7	8	9	10	11
1	0.50	0.11	0.29	0.33	0.20	0.22	0.34	0.23	0.23	0.33	1.00
2	0.33	0.07	0.19	0.23	0.12	0.20	0.17	0.10	0.22	0.14	1.00
3	0.55	0.08	0.22	0.34	0.24	0.26	0.36	0.33	0.17	0.00	1.00
4	0.46	0.07	0.19	0.33	0.14	0.38	0.27	0.27	0.25	0.00	1.00
5	0.50	0.08	0.23	0.18	0.14	0.25	0.33	0.50	0.00	0.00	1.00
6	0.48	0.00	0.13	0.35	0.31	0.00	0.44	0.20	0.75	0.00	1.00
7	0.38	0.10	0.22	0.19	0.06	0.12	0.21	0.18	0.22	0.14	1.00
8	0.44	0.00	0.27	0.36	0.29	0.00	0.20	0.25	0.00	0.33	1.00
9	0.47	0.10	0.33	0.17	0.40	0.00	0.33	0.50	0.00	1.00	0.00
10	0.58	0.00	0.60	0.00	0.00	0.50	1.00	0.00	0.00	0.00	0.00
11	0.30	0.05	0.17	0.17	0.21	0.16	0.19	0.23	0.20	0.00	1.00

FREQUENCIES IN THE BINARY MATRIX EXPRESSED AS PROBABILITIES OF THE ROW TOTALS

	1	2	3	4	5	6	7	8	9	10	11
1	0.50	0.05	0.13	0.10	0.04	0.04	0.04	0.02	0.01	0.02	0.03
2	0.33	0.05	0.12	0.12	0.05	0.07	0.05	0.02	0.05	0.02	0.14
3	0.55	0.03	0.09	0.11	0.05	0.04	0.04	0.03	0.01	0.00	0.04
4	0.46	0.04	0.10	0.13	0.04	0.09	0.04	0.03	0.02	0.00	0.06
5	0.50	0.04	0.10	0.06	0.04	0.06	0.06	0.06	0.00	0.00	0.06
6	0.48	0.00	0.07	0.16	0.09	0.00	0.09	0.02	0.07	0.00	0.02
7	0.38	0.06	0.12	0.08	0.02	0.04	0.06	0.04	0.04	0.02	0.12
8	0.44	0.00	0.15	0.15	0.07	0.00	0.04	0.04	0.00	0.04	0.07
9	0.47	0.05	0.16	0.05	0.11	0.00	0.05	0.05	0.00	0.05	0.00
10	0.58	0.00	0.25	0.00	0.00	0.08	0.08	0.00	0.00	0.00	0.00
11	0.30	0.04	0.11	0.09	0.09	0.06	0.06	0.06	0.04	0.00	0.15

FREQUENCIES IN THE BINARY MATRIX EXPRESSED AS PROBABILITIES OF THE COLUMN TOTALS

	1	2	3	4	5	6	7	8	9	10	11
1	0.50	0.58	0.52	0.46	0.42	0.40	0.44	0.33	0.37	0.67	0.30
2	0.03	0.05	0.04	0.05	0.04	0.07	0.04	0.04	0.11	0.08	0.11
3	0.14	0.09	0.09	0.12	0.12	0.12	0.10	0.11	0.05	0.00	0.09
4	0.10	0.09	0.09	0.13	0.08	0.21	0.08	0.11	0.11	0.00	0.11
5	0.05	0.05	0.04	0.03	0.04	0.07	0.06	0.11	0.00	0.00	0.06
6	0.04	0.00	0.03	0.07	0.08	0.00	0.08	0.04	0.16	0.00	0.02
7	0.04	0.07	0.05	0.04	0.02	0.05	0.06	0.07	0.11	0.08	0.11
8	0.03	0.00	0.03	0.04	0.04	0.00	0.02	0.04	0.00	0.08	0.04
9	0.02	0.02	0.03	0.01	0.04	0.00	0.02	0.04	0.00	0.08	0.00
10	0.01	0.00	0.03	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00
11	0.03	0.05	0.05	0.05	0.10	0.07	0.06	0.11	0.11	0.00	0.15

```
***A
JOB
MRC 001/00001003/ SR DISTANCE R.J.BRADLEY.
EXECUTION 2 MINUTES
COMPILER AA


begin
integer array  m(1:30,1:23)
integer i,j,f,n,set
real e,total
cycle i=1,1,30
cycle j=1,1,23
m(i,j)=0
repeat
repeat
repeat
total=0
1:  set= 0
2:  read (e)
-> 3 if e= -3
-> 1 if 150<e<200
-> 2 if e< 50
total=total +1
f= intpt(e*0.1)
f= 23  if f>23
set=set+1
->1 if set ≥ 30
m(set,f) = m(set,f) +1
-> 2
3:  newlines (4)
caption  frequencies ≴ after ≴  SR
newlines (2)
cycle i= 1,1,23
print (i,4,0)
repeat
newlines (2)
cycle i=1,1,30
newline
cycle j=1,1,23
print (m(i,j),4,0)
repeat
repeat
newlines (4)
caption  overall ≴ probabilities  ≴ after ≴  SR
newlines (2)
cycle i= 1,1,23
print (i,4,0)
repeat
```

```
newlines (2)
total= 1/total
cycle i=1,1,30
newline
cycle j=1,1,23
print (m(i,j)*total,1,2)
repeat
repeat
newlines (4)
caption 2nd ♯ order ♯ IRTs ♯ per ♯ OP
newlines (2)
cycle i=1,1,23
print (i,4,0)
repeat
newlines (2)
cycle i=1,1,30
newline
cycle n=1,1,23
e=0
cycle j=n,1,23
e=e +m(i,j)
repeat
-> 7 if e< 0
e=1/e
7:  print (m(i,n)*e,1,2)
repeat
repeat
newlines (4)
caption frequencies ♯ expressed ♯ as ♯ row ♯ probabilities
newlines (2)
cycle i= 1,1,23
print (i,3,0)
space
repeat
newline
cycle i=1,1,30
newline
e=0
cycle j=1,1,23
e=e+ m(i,j)
repeat
-> 6 if e<0
e=1/e
6: cycle j= 1,1,23
print (m(i,j)*e,1,2)
repeat
repeat
newlines (4)
```

```
caption frequencies ≠ expressed ≠ as ≠ column ≠ probabilities
newlines (2)
cycle i= 1,1,23
print (i,3,0)
space
repeat
newline
cycle i=1,1,30
newline
cycle j=1,1,23
e=0
cycle n=1,1,30
e=e +m(n,j)
repeat
-> 9 if e<0
e=1/e
9: print (m(i,j)*e,1,2)
repeat
repeat
end of program
```

RUNS OF NON-REINFORCED RESPONSES

	5	6	7	8	9	10	11	12	13	14	20	21	22	23+
1	0	0	2	2	4	10	13	41	147	281	1	4	1	11
2	3	2	3	5	9	7	28	61	95	100	7	5	5	27
3	1	0	1	5	9	14	27	41	54	57	8	5	4	16
4	1	0	0	1	5	13	19	30	38	47	4	4	2	6
5	1	0	4	1	4	10	9	13	31	21	5	1	2	10
6	0	0	2	0	3	9	6	13	12	10	3	3	0	7
7	0	0	0	2	1	5	10	7	3	9	1	2	1	6
8	0	0	0	4	2	2	1	5	10	3	1	0	0	4
9	0	0	0	0	0	2	7	5	0	7	0	0	1	2
10	1	0	0	1	0	1	4	5	2	1	0	0	0	0
11	0	0	0	0	0	0	3	4	4	1	0	0	0	0
12	0	0	0	0	1	0	1	1	3	2	0	0	0	0
13	0	0	0	0	1	1	1	1	2	2	0	0	0	0
14	0	0	0	0	0	1	1	1	1	1	0	0	0	0
15	0	0	0	0	0	0	0	1	1	0	0	0	0	1
16	0	0	0	0	0	0	0	0	1	1	0	0	0	0
17	0	0	0	0	0	0	0	0	2	0	0	0	0	0
18	0	0	0	0	0	0	0	1	1	0	0	0	0	0
19	0	0	0	0	0	0	0	1	0	0	0	0	0	0
20	0	0	0	0	0	1	0	0	0	0	0	0	0	0
21	0	0	0	0	0	1	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	1	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RUNS OF NON-REINFORCED RESPONSES

	5	6	7	8	9	10	11	12	13	14	20	21	22	23+
1	3	2	1	3	8	24	52	131	383	800	27	17	24	131
2	1	2	3	11	24	51	97	172	244	216	35	30	15	68
3	1	1	4	8	15	50	52	99	120	145	21	18	8	52
4	0	0	2	3	12	21	48	69	77	82	10	8	8	24
5	0	0	3	2	6	15	21	40	43	61	8	6	6	20
6	1	0	2	2	2	16	18	23	26	26	4	5	3	15
7	0	1	0	0	4	9	11	16	20	17	5	3	2	7
8	0	0	2	3	2	2	10	6	15	14	1	4	0	3
9	1	0	0	0	1	3	3	9	9	5	0	1	2	5
10	1	0	0	0	0	4	3	4	7	3	0	2	1	0
11	0	0	0	0	3	1	1	4	6	4	0	0	1	2
12	0	0	0	1	3	0	1	1	3	1	1	0	1	1
13	0	0	0	0	1	3	1	2	1	1	1	0	0	0
14	0	0	0	0	0	1	0	0	1	1	0	0	1	0
15	0	0	0	0	0	0	0	0	0	1	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RUNS OF REINFORCEMENT RAT F10

	15	16	17	18	19
1	564	404	311	206	131
2	364	156	65	35	26
3	146	49	26	14	13
4	61	23	6	10	4
5	21	13	6	5	2
6	17	5	1	0	2
7	8	2	1	1	0
8	3	2	0	0	0
9	1	0	0	0	0
10	1	0	0	0	0
11	0	0	0	0	0

RUNS OF REINFORCEMENT RAT F9

	15	16	17	18	19
1	174	157	98	47	40
2	137	66	17	11	2
3	67	21	6	4	1
4	36	12	5	2	1
5	18	12	2	2	0
6	16	5	2	1	0
7	11	1	1	0	0
8	3	3	1	0	0
9	2	0	0	0	0
10	1	0	0	0	0
11	0	0	0	0	0

```
***A
JOB
MRC 001/00001008 PROBE INFORMATIC 3 BY 6TH R.J.BRADLEY
OUTPUT
0 LINE PRINTER 1500 LINES
EXECUTION 5 MINUTES
COMPILER AA

begin
integer array x(-1:2,-1:2,-1:2,0:2), y(-1:2,-1:2,0:2), z(-1:2,0:2),
v(0:2)
integer array u(-1:2,-1:2,-1:2,-1:2,0:2), w(-1:2,-1:2,-1:2,-1:2,
-1:2,0:2)
integer f,i,j,k,l,r,t,dog,hen,cat,pig,sow,total
real a,b,c,d,h,s,e,g
cycle i=0,1,2
v(i)=0
cycle j=0,1,2
z(i,j)=0
cycle k=0,1,2
y(i,j,k)= 0
cycle l=0,1,2
x(i,j,k,l)=0
cycle r=0,1,2
u(i,j,k,l,r)=0
cycle t= 0,1,2
w(i,j,k,l,r,t)=0
repeat
  repeat
    repeat
      repeat
        repeat
          repeat
dog=-1
hen=-1
cat=-1
pig=-1
sow=-1
total=0
a=0
b=0
c=0
d=0
h=0
s=0
g=1/log(2)
1: read (e)
```

```
total=total +1
->2 if e=-3
f=2
if e<50thenf=0
if 150<e<200thenf=1
v(f)=v(f)+1
z(cat,f)=z(cat,f)+1
y(hen,cat,f)=y(hen,cat,f)+1
x(dog,hen,cat,f)=x(dog,hen,cat,f)+1
u(pig,dog,hen,cat,f)=u(pig,dog,hen,cat,f)+1
w(sow,pig,dog,hen,cat,f)=w(sow,pig,dog,hen,cat,f)+1
sow=pig
pig=dog
dog=hen
hen=cat
cat=f
->1
2: caption  frequencies ś and ś conditional ś probabilities ś
3 ś categories
newline
caption  burst ś (0) ś śś  reinforced ś (1) śśś  non-reinforcedś(2)
cycle i=0,1,2
-> 12 if v(i)=0
newline
print (i,1,0)
spaces (2)
print (v(i),4,0)
spaces (2)
print (v(i)/total,0,4)
a=a-v(i)/total*log(v(i)/total)/g
cycle j=0,1,2
-> 11 if z(i,j)=0
newline
spaces (15)
print (i,1,0)
print (j,1,0)
spaces (2)
print (z(i,j),4,0)
spaces (2)
print (z(i,j)/v(i),0,4)
b=b-z(i,j)/(total-1)*log(z(i,j)/(total-1))/g
3: cycle k=0,1,2
-> 10 if y(i,j,k)=0
newline
spaces (30)
print (i,1,0)
print (j,1,0)
print (k,1,0)
```

```
spaces (2)
print (y(i,j,k),4,0)
spaces (2)
print (y(i,j,k)/z(i,j), 0,4)
c=c-y(i,j,k)/(total-2)*log(y(i,j,k)/(total-2))/g
4:cycle l=0,1,2
-> 9 if x(i,j,k,l)=0
newline
spaces (50)
print (i,1,0)
print (j,1,0)
print (k,1,0)
print (l,1,0)
spaces (2)
print (x(i,j,k,l),4,0)
spaces (2)
print (x(i,j,k,l)/y(i,j,k),0,4)
d=d-x(i,j,k,l)/(total-3)*log(x(i,j,k,l)/(total-3))/g
5:cycle r=0,1,2
-> 8 if u(i,j,k,l,r)=0
newline
spaces (70)
print (i,1,0)
print (j,1,0)
print (k,1,0)
print (l,1,0)
print (r,1,0)
spaces (2)
print (u(i,j,k,l,r),4,0)
spaces (2)
print (u(i,j,k,l,r)/x(i,j,k,l),0,4)
h=h - u(i,j,k,l,r)/(total-4)*log(u(i,j,k,l,r)/(total-4))/g
6:cycle t= 0,1,2
-> 7 if w(i,j,k,l,r,t)=0
newline
spaces (90)
print (i,1,0)
print (j,1,0)
print (k,1,0)
print (l,1,0)
print (r,1,0)
print (t,1,0)
spaces (2)
print (w(i,j,k,l,r,t),4,0)
spaces (2)
print (w(i,j,k,l,r,t)/u(i,j,k,l,r),0,4)
s=s - w(i,j,k,l,r,t)/(total-5)*log(w(i,j,k,l,r,t)/(total-5))/g
7:repeat
```

```
8:repeat
9:repeat
10:  repeat
11:    repeat
12:      repeat
s=s-h
h=h-d
d=d-c
c=c-b
b=b-a
newlines (3)
caption  the ∮ end
newlines (4)
caption averaged ∮ uncertainties
newlines (2)
caption 6th ∮ order
spaces (5)
print (s,1,8)
newlines (4)
caption 5th ∮ order
spaces (5)
print (h,1,8)
newlines (4)
caption 4th ∮ order
spaces (5)
print (d,1,8)
newlines (4)
caption 3rd ∮ order
spaces (5)
print (c,1,8)
newlines (4)
caption 2nd ∮ order
spaces (5)
print (b,1,8)
newlines (4)
caption 1st ∮ order
spaces (5)
print (a,1,8)
end of program
```

FREQUENCIES AND CONDITIONAL PROBABILITIES
3 CATEGORIES

BURST (0)	REINFORCED (1)		NON-REINFORCED (2)		
0	291	0.0406	0 1 0 2 1 1	1	1.0000
0 0	8	0.0275	0 1 0 2 2	1	0.5000
0 0 1	3	0.3750	0 1 0 2 2 1	1	1.0000
0 0 1 1	2	0.6667	0 1 1	54	0.4463
0 0 1 1 1	1	0.5000	0 1 1 0	2	0.0370
0 0 1 1 1 2	1	1.0000	0 1 1 0 2	2	1.0000
0 0 1 1 2	1	0.5000	0 1 1 0 2 1	1	0.5000
0 0 1 1 2 2	1	1.0000	0 1 1 0 2 2	1	0.5000
0 0 1 2	1	0.3333	0 1 1 1	23	0.4259
0 0 1 2 2	1	1.0000	0 1 1 1 0	1	0.0435
0 0 1 2 2 1	1	1.0000	0 1 1 1 0 1	1	1.0000
0 0 2	5	0.6250	0 1 1 1 1	12	0.5217
0 0 2 0	2	0.4000	0 1 1 1 1 1	5	0.4167
0 0 2 0 1	2	1.0000	0 1 1 1 1 2	7	0.5833
0 0 2 0 1 1	1	0.5000	0 1 1 1 2	10	0.4348
0 0 2 0 1 2	1	0.5000	0 1 1 1 2 1	4	0.4000
0 0 2 1	1	0.2000	0 1 1 1 2 2	6	0.6000
0 0 2 1 2	1	1.0000	0 1 1 2	29	0.5370
0 0 2 1 2 1	1	1.0000	0 1 1 2 0	3	0.1034
0 0 2 2	2	0.4000	0 1 1 2 0 1	1	0.3333
0 0 2 2 2	2	1.0000	0 1 1 2 0 2	2	0.6667
0 0 2 2 2 1	1	0.5000	0 1 1 2 1	9	0.3103
0 0 2 2 2 2	1	0.5000	0 1 1 2 1 1	4	0.4444
0 1	121	0.4158	0 1 1 2 1 2	5	0.5556
0 1 0	3	0.0248	0 1 1 2 2	17	0.5862
0 1 0 1	1	0.3333	0 1 1 2 2 0	3	0.1765
0 1 0 1 1	1	1.0000	0 1 1 2 2 1	4	0.2353
0 1 0 1 1 2	1	1.0000	0 1 1 2 2 2	10	0.5882
0 1 0 2	2	0.6667	0 1 2	64	0.5289
0 1 0 2 1	1	0.5000	0 1 2 0	5	0.0781

0 1 2 0 1	2	0.4000
0 1 2 0 1 2	2	1.0000
0 1 2 0 2	3	0.6000
0 1 2 0 2 1	1	0.3333
0 1 2 0 2 2	2	0.6667
0 1 2 1	26	0.4062
0 1 2 1 1	8	0.3077
0 1 2 1 1 1	1	0.1250
0 1 2 1 1 2	7	0.8750
0 1 2 1 2	18	0.6923
0 1 2 1 2 1	11	0.6111
0 1 2 1 2 2	7	0.3889
0 1 2 2	33	0.5156
0 1 2 2 0	2	0.0606
0 1 2 2 0 1	1	0.5000
0 1 2 2 0 2	1	0.5000
0 1 2 2 1	13	0.3939
0 1 2 2 1 1	7	0.5385
0 1 2 2 1 2	6	0.4615
0 1 2 2 2	18	0.5455
0 1 2 2 2 0	2	0.1111
0 1 2 2 2 1	6	0.3333
0 1 2 2 2 2	10	0.5556
0 2	162	0.5567
0 2 0	10	0.0617
0 2 0 1	4	0.4000
0 2 0 1 1	3	0.7500
0 2 0 1 1 1	1	0.3333
0 2 0 1 1 2	2	0.6667
0 2 0 1 2	1	0.2500
0 2 0 1 2 0	1	1.0000
0 2 0 2	6	0.6000
0 2 0 2 1	2	0.3333
0 2 0 2 1 1	2	1.0000
0 2 0 2 2	4	0.6667
0 2 0 2 2 1	3	0.7500
0 2 0 2 2 2	1	0.2500
0 2 1	66	0.4074
0 2 1 1	29	0.4394
0 2 1 1 1	8	0.2759
0 2 1 1 1 1	6	0.7500
0 2 1 1 1 2	2	0.2500
0 2 1 1 2	21	0.7241
0 2 1 1 2 0	8	0.3810
0 2 1 1 2 1	1	0.0476
0 2 1 1 2 2	12	0.5714
0 2 1 2	37	0.5606
0 2 1 2 0	2	0.0541
0 2 1 2 0 2	2	1.0000
0 2 1 2 1	14	0.3784
0 2 1 2 1 1	6	0.4286
0 2 1 2 1 2	8	0.5714
0 2 1 2 2	21	0.5676
0 2 1 2 2 0	4	0.1905
0 2 1 2 2 1	6	0.2857
0 2 1 2 2 2	11	0.5238
0 2 2	86	0.5309
0 2 2 0	6	0.0698
0 2 2 0 1	1	0.1667
0 2 2 0 1 1	1	1.0000

0 2 2 0 2	5	0.8333
0 2 2 0 2 1	2	0.4000
0 2 2 0 2 2	3	0.6000
0 2 2 1	33	0.3837
0 2 2 1 1	13	0.3939
0 2 2 1 1 1	2	0.1538
0 2 2 1 1 2	11	0.8462
0 2 2 1 2	20	0.6061
0 2 2 1 2 0	2	0.1000
0 2 2 1 2 1	6	0.3000
0 2 2 1 2 2	12	0.6000
0 2 2 2	47	0.5465
0 2 2 2 0	3	0.0638
0 2 2 2 0 0	1	0.3333
0 2 2 2 0 1	2	0.6667
0 2 2 2 1	12	0.2553
0 2 2 2 1 1	6	0.5000
0 2 2 2 1 2	6	0.5000
0 2 2 2 2	32	0.6809
0 2 2 2 2 0	1	0.0312
0 2 2 2 2 1	14	0.4375
0 2 2 2 2 2	17	0.5313
1	2697	0.3758
1 0	28	0.0104
1 0 1	11	0.3929
1 0 1 1	7	0.6364
1 0 1 1 1	3	0.4286
1 0 1 1 1 1	2	0.6667
1 0 1 1 1 2	1	0.3333
1 0 1 1 2	4	0.5714
1 0 1 1 2 1	3	0.7500
1 0 1 1 2 2	1	0.2500
1 0 1 2	4	0.3636
1 0 1 2 1	1	0.2500
1 0 1 2 1 1	1	1.0000
1 0 1 2 2	3	0.7500
1 0 1 2 2 2	3	1.0000
1 0 2	17	0.6071
1 0 2 1	7	0.4118
1 0 2 1 1	5	0.7143
1 0 2 1 1 1	2	0.4000
1 0 2 1 1 2	3	0.6000
1 0 2 1 2	2	0.2857
1 0 2 1 2 1	1	0.5000
1 0 2 1 2 2	1	0.5000
1 0 2 2	10	0.5882
1 0 2 2 1	5	0.5000
1 0 2 2 1 1	1	0.2000
1 0 2 2 1 2	4	0.8000
1 0 2 2 2	5	0.5000
1 0 2 2 2 2	5	1.0000
1 1	1085	0.4023
1 1 0	19	0.0175
1 1 0 1	8	0.4211
1 1 0 1 1	6	0.7500
1 1 0 1 1 1	3	0.5000
1 1 0 1 1 2	3	0.5000
1 1 0 1 2	2	0.2500
1 1 0 1 2 1	1	0.5000
1 1 0 1 2 2	1	0.5000

1 1 0 2	11	0.5789
1 1 0 2 1	4	0.3636
1 1 0 2 1 1	3	0.7500
1 1 0 2 1 2	1	0.2500
1 1 0 2 2	7	0.6364
1 1 0 2 2 1	3	0.4286
1 1 0 2 2 2	4	0.5714
1 1 1	442	0.4074
1 1 1 0	11	0.0249
1 1 1 0 1	6	0.5455
1 1 1 0 1 1	6	1.0000
1 1 1 0 2	5	0.4545
1 1 1 0 2 2	5	1.0000
1 1 1 1	195	0.4412
1 1 1 1 0	6	0.0308
1 1 1 1 0 1	2	0.3333
1 1 1 1 0 2	4	0.6667
1 1 1 1 1	91	0.4667
1 1 1 1 1 0	4	0.0440
1 1 1 1 1 1	44	0.4835
1 1 1 1 1 2	43	0.4725
1 1 1 1 2	98	0.5026
1 1 1 1 2 0	15	0.1531
1 1 1 1 2 1	31	0.3163
1 1 1 1 2 2	52	0.5306
1 1 1 2	236	0.5339
1 1 1 2 0	26	0.1102
1 1 1 2 0 0	1	0.0385
1 1 1 2 0 1	12	0.4615
1 1 1 2 0 2	13	0.5000
1 1 1 2 1	81	0.3432
1 1 1 2 1 1	32	0.3951
1 1 1 2 1 2	49	0.6049
1 1 1 2 2	129	0.5466
1 1 1 2 2 0	10	0.0775
1 1 1 2 2 1	42	0.3256
1 1 1 2 2 2	77	0.5969
1 1 2	624	0.5751
1 1 2 0	65	0.1042
1 1 2 0 0	1	0.0154
1 1 2 0 0 2	1	1.0000
1 1 2 0 1	31	0.4769
1 1 2 0 1 1	16	0.5161
1 1 2 0 1 2	15	0.4839
1 1 2 0 2	33	0.5077
1 1 2 0 2 0	3	0.0909
1 1 2 0 2 1	10	0.3030
1 1 2 0 2 2	20	0.6061
1 1 2 1	225	0.3606
1 1 2 1 0	2	0.0089
1 1 2 1 0 2	2	1.0000
1 1 2 1 1	98	0.4356
1 1 2 1 1 0	1	0.0102
1 1 2 1 1 1	42	0.4286
1 1 2 1 1 2	55	0.5612
1 1 2 1 2	125	0.5556
1 1 2 1 2 0	12	0.0960
1 1 2 1 2 1	51	0.4080
1 1 2 1 2 2	62	0.4960
1 1 2 2	334	0.5353

1 1 2 2 0	26	0.0778
1 1 2 2 0 1	14	0.5385
1 1 2 2 0 2	12	0.4615
1 1 2 2 1	122	0.3653
1 1 2 2 1 1	46	0.3770
1 1 2 2 1 2	76	0.6230
1 1 2 2 2	186	0.5569
1 1 2 2 2 0	9	0.0484
1 1 2 2 2 1	73	0.3925
1 1 2 2 2 2	104	0.5591
1 2	1584	0.5873
1 2 0	121	0.0764
1 2 0 0	2	0.0165
1 2 0 0 2	2	1.0000
1 2 0 0 2 0	1	0.5000
1 2 0 0 2 2	1	0.5000
1 2 0 1	53	0.4380
1 2 0 1 0	2	0.0377
1 2 0 1 0 1	1	0.5000
1 2 0 1 0 2	1	0.5000
1 2 0 1 1	21	0.3962
1 2 0 1 1 0	1	0.0476
1 2 0 1 1 1	9	0.4286
1 2 0 1 1 2	11	0.5238
1 2 0 1 2	30	0.5660
1 2 0 1 2 0	2	0.0667
1 2 0 1 2 1	12	0.4000
1 2 0 1 2 2	16	0.5333
1 2 0 2	66	0.5455
1 2 0 2 0	5	0.0758
1 2 0 2 0 1	2	0.4000
1 2 0 2 0 2	3	0.6000
1 2 0 2 1	26	0.3939
1 2 0 2 1 1	9	0.3462
1 2 0 2 1 2	17	0.6538
1 2 0 2 2	35	0.5303
1 2 0 2 2 0	3	0.0857
1 2 0 2 2 1	13	0.3714
1 2 0 2 2 2	19	0.5429
1 2 1	576	0.3636
1 2 1 0	4	0.0069
1 2 1 0 2	4	1.0000
1 2 1 0 2 1	2	0.5000
1 2 1 0 2 2	2	0.5000
1 2 1 1	235	0.4080
1 2 1 1 0	3	0.0128
1 2 1 1 0 1	1	0.3333
1 2 1 1 0 2	2	0.6667
1 2 1 1 1	99	0.4213
1 2 1 1 1 0	2	0.0202
1 2 1 1 1 1	44	0.4444
1 2 1 1 1 2	53	0.5354
1 2 1 1 2	133	0.5660
1 2 1 1 2 0	13	0.0977
1 2 1 1 2 1	47	0.3534
1 2 1 1 2 2	73	0.5489
1 2 1 2	337	0.5851
1 2 1 2 0	24	0.0712
1 2 1 2 0 0	1	0.0417
1 2 1 2 0 1	7	0.2917

1 2 1 2 0 2	16	0.6667
1 2 1 2 1	136	0.4036
1 2 1 2 1 0	2	0.0147
1 2 1 2 1 1	50	0.3676
1 2 1 2 1 2	84	0.6176
1 2 1 2 2	177	0.5252
1 2 1 2 2 0	8	0.0452
1 2 1 2 2 1	55	0.3107
1 2 1 2 2 2	114	0.6441
1 2 2	887	0.5600
1 2 2 0	57	0.0643
1 2 2 0 0	4	0.0702
1 2 2 0 0 1	2	0.5000
1 2 2 0 0 2	2	0.5000
1 2 2 0 1	24	0.4211
1 2 2 0 1 0	1	0.0417
1 2 2 0 1 1	10	0.4167
1 2 2 0 1 2	13	0.5417
1 2 2 0 2	29	0.5088
1 2 2 0 2 0	2	0.0690
1 2 2 0 2 1	16	0.5517
1 2 2 0 2 2	11	0.3793
1 2 2 1	309	0.3484
1 2 2 1 0	2	0.0065
1 2 2 1 0 1	2	1.0000
1 2 2 1 1	129	0.4175
1 2 2 1 1 0	1	0.0078
1 2 2 1 1 1	46	0.3566
1 2 2 1 1 2	82	0.6357
1 2 2 1 2	178	0.5761
1 2 2 1 2 0	10	0.0562
1 2 2 1 2 1	68	0.3820
1 2 2 1 2 2	100	0.5618
1 2 2 2	521	0.5874
1 2 2 2 0	21	0.0403
1 2 2 2 0 0	1	0.0476
1 2 2 2 0 1	5	0.2381
1 2 2 2 0 2	15	0.7143
1 2 2 2 1	194	0.3724
1 2 2 2 1 1	71	0.3660
1 2 2 2 1 2	123	0.6340
1 2 2 2 2	306	0.5873
1 2 2 2 2 0	12	0.0392
1 2 2 2 2 1	101	0.3301
1 2 2 2 2 2	193	0.6307
2	4187	0.5835
2 0	255	0.0609
2 0 0	8	0.0314
2 0 0 1	3	0.3750
2 0 0 1 1	2	0.6667
2 0 0 1 1 1	1	0.5000
2 0 0 1 1 2	1	0.5000
2 0 0 1 2	1	0.3333
2 0 0 1 2 2	1	1.0000
2 0 0 2	5	0.6250
2 0 0 2 0	2	0.4000
2 0 0 2 0 1	2	1.0000
2 0 0 2 1	1	0.2000
2 0 0 2 1 2	1	1.0000
2 0 0 2 2	2	0.4000

2 0 0 2 2 2	2	1.0000
2 0 1	107	0.4196
2 0 1 0	3	0.0280
2 0 1 0 1	1	0.3333
2 0 1 0 1 1	1	1.0000
2 0 1 0 2	2	0.6667
2 0 1 0 2 1	1	0.5000
2 0 1 0 2 2	1	0.5000
2 0 1 1	45	0.4206
2 0 1 1 0	2	0.0444
2 0 1 1 0 2	2	1.0000
2 0 1 1 1	19	0.4222
2 0 1 1 1 0	1	0.0526
2 0 1 1 1 1	10	0.5263
2 0 1 1 1 2	8	0.4211
2 0 1 1 2	24	0.5333
2 0 1 1 2 0	3	0.1250
2 0 1 1 2 1	6	0.2500
2 0 1 1 2 2	15	0.6250
2 0 1 2	59	0.5514
2 0 1 2 0	5	0.0847
2 0 1 2 0 1	2	0.4000
2 0 1 2 0 2	3	0.6000
2 0 1 2 1	25	0.4237
2 0 1 2 1 1	7	0.2800
2 0 1 2 1 2	18	0.7200
2 0 1 2 2	29	0.4915
2 0 1 2 2 0	2	0.0690
2 0 1 2 2 1	12	0.4138
2 0 1 2 2 2	15	0.5172
2 0 2	140	0.5490
2 0 2 0	8	0.0571
2 0 2 0 1	2	0.2500
2 0 2 0 1 1	2	1.0000
2 0 2 0 2	6	0.7500
2 0 2 0 2 1	2	0.3333
2 0 2 0 2 2	4	0.6667
2 0 2 1	58	0.4143
2 0 2 1 1	24	0.4138
2 0 2 1 1 1	6	0.2500
2 0 2 1 1 2	18	0.7500
2 0 2 1 2	34	0.5862
2 0 2 1 2 0	2	0.0588
2 0 2 1 2 1	12	0.3529
2 0 2 1 2 2	20	0.5882
2 0 2 2	74	0.5286
2 0 2 2 0	6	0.0811
2 0 2 2 0 1	1	0.1667
2 0 2 2 0 2	5	0.8333
2 0 2 2 1	28	0.3784
2 0 2 2 1 1	12	0.4286
2 0 2 2 1 2	16	0.5714
2 0 2 2 2	40	0.5405
2 0 2 2 2 0	3	0.0750
2 0 2 2 2 1	11	0.2750
2 0 2 2 2 2	26	0.6500
2 1	1491	0.3561
2 1 0	6	0.0040
2 1 0 1	2	0.3333
2 1 0 1 2	2	1.0000

2 1 0 1 2 2	2	1.0000
2 1 0 2	4	0.6667
2 1 0 2 1	2	0.5000
2 1 0 2 1 1	1	0.5000
2 1 0 2 1 2	1	0.5000
2 1 0 2 2	2	0.5000
2 1 0 2 2 1	1	0.5000
2 1 0 2 2 2	1	0.5000
2 1 1	589	0.3950
2 1 1 0	6	0.0102
2 1 1 0 1	2	0.3333
2 1 1 0 1 2	2	1.0000
2 1 1 0 2	4	0.6667
2 1 1 0 2 1	3	0.7500
2 1 1 0 2 2	1	0.2500
2 1 1 1	224	0.3803
2 1 1 1 0	4	0.0179
2 1 1 1 0 1	3	0.7500
2 1 1 1 0 2	1	0.2500
2 1 1 1 1	92	0.4107
2 1 1 1 1 0	2	0.0217
2 1 1 1 1 1	42	0.4565
2 1 1 1 1 2	48	0.5217
2 1 1 1 2	128	0.5714
2 1 1 1 2 0	11	0.0859
2 1 1 1 2 1	46	0.3594
2 1 1 1 2 2	71	0.5547
2 1 1 2	359	0.6095
2 1 1 2 0	36	0.1003
2 1 1 2 0 1	18	0.5000
2 1 1 2 0 2	18	0.5000
2 1 1 2 1	135	0.3760
2 1 1 2 1 0	2	0.0148
2 1 1 2 1 1	62	0.4593
2 1 1 2 1 2	71	0.5259
2 1 1 2 2	188	0.5237
2 1 1 2 2 0	13	0.0691
2 1 1 2 2 1	76	0.4043
2 1 1 2 2 2	99	0.5266
2 1 2	896	0.6009
2 1 2 0	51	0.0569
2 1 2 0 0	1	0.0196
2 1 2 0 0 2	1	1.0000
2 1 2 0 1	20	0.3922
2 1 2 0 1 0	2	0.1000
2 1 2 0 1 1	5	0.2500
2 1 2 0 1 2	13	0.6500
2 1 2 0 2	30	0.5882
2 1 2 0 2 0	2	0.0667
2 1 2 0 2 1	15	0.5000
2 1 2 0 2 2	13	0.4333
2 1 2 1	325	0.3627
2 1 2 1 0	2	0.0062
2 1 2 1 0 2	2	1.0000
2 1 2 1 1	129	0.3969
2 1 2 1 1 0	2	0.0155
2 1 2 1 1 1	56	0.4341
2 1 2 1 1 2	71	0.5504
2 1 2 1 2	194	0.5969
2 1 2 1 2 0	12	0.0619

2 1 2 1 2 1	74	0.3814
2 1 2 1 2 2	108	0.5567
2 1 2 2	520	0.5804
2 1 2 2 0	29	0.0558
2 1 2 2 0 0	4	0.1379
2 1 2 2 0 1	9	0.3103
2 1 2 2 0 2	16	0.5517
2 1 2 2 1	174	0.3346
2 1 2 2 1 0	2	0.0115
2 1 2 2 1 1	76	0.4368
2 1 2 2 1 2	96	0.5517
2 1 2 2 2	317	0.6096
2 1 2 2 2 0	10	0.0315
2 1 2 2 2 1	115	0.3628
2 1 2 2 2 2	192	0.6057
2 2	2440	0.5828
2 2 0	124	0.0508
2 2 0 0	6	0.0484
2 2 0 0 1	3	0.5000
2 2 0 0 1 1	2	0.6667
2 2 0 0 1 2	1	0.3333
2 2 0 0 2	3	0.5000
2 2 0 0 2 0	1	0.3333
2 2 0 0 2 1	1	0.3333
2 2 0 0 2 2	1	0.3333
2 2 0 1	50	0.4032
2 2 0 1 0	1	0.0200
2 2 0 1 0 2	1	1.0000
2 2 0 1 1	21	0.4200
2 2 0 1 1 0	1	0.0476
2 2 0 1 1 1	9	0.4286
2 2 0 1 1 2	11	0.5238
2 2 0 1 2	28	0.5600
2 2 0 1 2 0	2	0.0714
2 2 0 1 2 1	13	0.4643
2 2 0 1 2 2	13	0.4643
2 2 0 2	68	0.5484
2 2 0 2 0	3	0.0441
2 2 0 2 0 2	3	1.0000
2 2 0 2 1	30	0.4412
2 2 0 2 1 1	13	0.4333
2 2 0 2 1 2	17	0.5667
2 2 0 2 2	35	0.5147
2 2 0 2 2 0	3	0.0857
2 2 0 2 2 1	12	0.3429
2 2 0 2 2 2	20	0.5714
2 2 1	849	0.3480
2 2 1 0	2	0.0024
2 2 1 0 1	2	1.0000
2 2 1 0 1 2	2	1.0000
2 2 1 1	325	0.3828
2 2 1 1 0	3	0.0092
2 2 1 1 0 1	11	0.3333
2 2 1 1 0 2	2	0.6667
2 2 1 1 1	117	0.3600
2 2 1 1 1 0	2	0.0171
2 2 1 1 1 1	42	0.3590
2 2 1 1 1 2	73	0.6239
2 2 1 1 2	205	0.6308
2 2 1 1 2 0	15	0.0732

2 2 1 1 2 1	87	0.4244
2 2 1 1 2 2	103	0.5024
2 2 1 2	522	0.6148
2 2 1 2 0	25	0.0479
2 2 1 2 0 1	13	0.5200
2 2 1 2 0 2	12	0.4800
2 2 1 2 1	175	0.3352
2 2 1 2 1 1	73	0.4171
2 2 1 2 1 2	102	0.5829
2 2 1 2 2	322	0.6169
2 2 1 2 2 0	17	0.0528
2 2 1 2 2 1	113	0.3509
2 2 1 2 2 2	192	0.5963
2 2 2	1466	0.6008
2 2 2 0	61	0.0416
2 2 2 0 0	2	0.0328
2 2 2 0 0 1	1	0.5000
2 2 2 0 0 2	1	0.5000
2 2 2 0 1	25	0.4098
2 2 2 0 1 1	10	0.4000
2 2 2 0 1 2	15	0.6000
2 2 2 0 2	34	0.5574
2 2 2 0 2 0	1	0.0294
2 2 2 0 2 1	12	0.3529
2 2 2 0 2 2	21	0.6176
2 2 2 1	507	0.3458
2 2 2 1 1	183	0.3609
2 2 2 1 1 0	2	0.0109
2 2 2 1 1 1	69	0.3770
2 2 2 1 1 2	112	0.6120
2 2 2 1 2	324	0.6391
2 2 2 1 2 0	13	0.0401
2 2 2 1 2 1	101	0.3117
2 2 2 1 2 2	210	0.6481
2 2 2 2	897	0.6119
2 2 2 2 0	37	0.0412
2 2 2 2 0 1	18	0.4865
2 2 2 2 0 2	19	0.5135
2 2 2 2 1	300	0.3344
2 2 2 2 1 1	105	0.3500
2 2 2 2 1 2	195	0.6500
2 2 2 2 2	559	0.6232
2 2 2 2 2 0	24	0.0429
2 2 2 2 2 1	185	0.3309
2 2 2 2 2 2	349	0.6243

FREQUENCIES AND CONDITIONAL PROBABILITIES
3 CATEGORIES

BURST (0)	REINFORCED (1)		NON-REINFORCED (2)		
0	342	0.1156	0 0 1 2 2	8	0.8000
0 0	69	0.2018	0 0 1 2 2 0	2	0.2500
0 0 0	11	0.1594	0 0 1 2 2 1	1	0.1250
0 0 0 0	2	0.1818	0 0 1 2 2 2	5	0.6250
0 0 0 0 2	2	1.0000	0 0 2	37	0.5362
0 0 0 0 2 2	2	1.0000	0 0 2 0	10	0.2703
0 0 0 1	3	0.2727	0 0 2 0 0	1	0.1000
0 0 0 1 1	3	1.0000	0 0 2 0 0 2	1	1.0000
0 0 0 1 1 1	2	0.6667	0 0 2 0 1	2	0.2000
0 0 0 1 1 2	1	0.3333	0 0 2 0 1 1	1	0.5000
0 0 0 2	6	0.5455	0 0 2 0 1 2	1	0.5000
0 0 0 2 1	1	0.1667	0 0 2 0 2	7	0.7000
0 0 0 2 1 1	1	1.0000	0 0 2 0 2 0	1	0.1429
0 0 0 2 2	5	0.8333	0 0 2 0 2 1	4	0.5714
0 0 0 2 2 1	3	0.6000	0 0 2 0 2 2	2	0.2857
0 0 0 2 2 2	2	0.4000	0 0 2 1	5	0.1351
0 0 1	21	0.3043	0 0 2 1 1	4	0.8000
0 0 1 1	11	0.5238	0 0 2 1 1 1	3	0.7500
0 0 1 1 1	7	0.6364	0 0 2 1 1 2	1	0.2500
0 0 1 1 1 1	4	0.5714	0 0 2 1 2	1	0.2000
0 0 1 1 1 2	3	0.4286	0 0 2 1 2 0	1	1.0000
0 0 1 1 2	4	0.3636	0 0 2 2	22	0.5946
0 0 1 1 2 0	2	0.5000	0 0 2 2 0	3	0.1364
0 0 1 1 2 1	1	0.2500	0 0 2 2 0 0	1	0.3333
0 0 1 1 2 2	1	0.2500	0 0 2 2 0 1	1	0.3333
0 0 1 2	10	0.4762	0 0 2 2 0 2	1	0.3333
0 0 1 2 0	1	0.1000	0 0 2 2 1	5	0.2273
0 0 1 2 0 1	1	1.0000	0 0 2 2 1 1	3	0.6000
0 0 1 2 1	1	0.1000	0 0 2 2 1 2	2	0.4000
0 0 1 2 1 2	1	1.0000	0 0 2 2 2	14	0.6364

0 0 2 2 2 0	2	0.1429
0 0 2 2 2 1	6	0.4286
0 0 2 2 2 2	6	0.4286
0 1	87	0.2544
0 1 1	54	0.6207
0 1 1 1	25	0.4630
0 1 1 1 1	17	0.6800
0 1 1 1 1 1	7	0.4118
0 1 1 1 1 2	10	0.5882
0 1 1 1 2	8	0.3200
0 1 1 1 2 0	3	0.3750
0 1 1 1 2 1	1	0.1250
0 1 1 1 2 2	4	0.5000
0 1 1 2	29	0.5370
0 1 1 2 0	8	0.2759
0 1 1 2 0 0	4	0.5000
0 1 1 2 0 2	4	0.5000
0 1 1 2 1	11	0.3793
0 1 1 2 1 1	3	0.2727
0 1 1 2 1 2	8	0.7273
0 1 1 2 2	10	0.3448
0 1 1 2 2 0	1	0.1000
0 1 1 2 2 1	2	0.2000
0 1 1 2 2 2	7	0.7000
0 1 2	33	0.3793
0 1 2 0	6	0.1818
0 1 2 0 0	3	0.5000
0 1 2 0 0 1	2	0.6667
0 1 2 0 0 2	1	0.3333
0 1 2 0 1	3	0.5000
0 1 2 0 1 1	3	1.0000
0 1 2 1	3	0.0909
0 1 2 1 2	3	1.0000
0 1 2 1 2 1	2	0.6667
0 1 2 1 2 2	1	0.3333
0 1 2 2	24	0.7273
0 1 2 2 0	6	0.2500
0 1 2 2 0 0	2	0.3333
0 1 2 2 0 2	4	0.6667
0 1 2 2 1	5	0.2083
0 1 2 2 1 1	1	0.2000
0 1 2 2 1 2	4	0.8000
0 1 2 2 2	13	0.5417
0 1 2 2 2 0	1	0.0769
0 1 2 2 2 1	2	0.1538
0 1 2 2 2 2	10	0.7692
0 2	186	0.5439
0 2 0	30	0.1613
0 2 0 0	4	0.1333
0 2 0 0 1	2	0.5000
0 2 0 0 1 2	2	1.0000
0 2 0 0 2	2	0.5000
0 2 0 0 2 0	1	0.5000
0 2 0 0 2 2	1	0.5000
0 2 0 1	6	0.2000
0 2 0 1 1	2	0.3333
0 2 0 1 1 2	2	1.0000
0 2 0 1 2	4	0.6667
0 2 0 1 2 0	2	0.5000
0 2 0 1 2 2	2	0.5000

0 2 0 2	20	0.6667
0 2 0 2 0	2	0.1000
0 2 0 2 0 2	2	1.0000
0 2 0 2 1	9	0.4500
0 2 0 2 1 1	4	0.4444
0 2 0 2 1 2	5	0.5556
0 2 0 2 2	9	0.4500
0 2 0 2 2 0	3	0.3333
0 2 0 2 2 1	2	0.2222
0 2 0 2 2 2	4	0.4444
0 2 1	55	0.2957
0 2 1 0	1	0.0182
0 2 1 0 0	1	1.0000
0 2 1 0 0 2	1	1.0000
0 2 1 1	27	0.4909
0 2 1 1 1	16	0.5926
0 2 1 1 1 1	9	0.5625
0 2 1 1 1 2	7	0.4375
0 2 1 1 2	11	0.4074
0 2 1 1 2 0	2	0.1818
0 2 1 1 2 1	1	0.0909
0 2 1 1 2 2	8	0.7273
0 2 1 2	27	0.4909
0 2 1 2 0	8	0.2963
0 2 1 2 0 0	2	0.2500
0 2 1 2 0 2	6	0.7500
0 2 1 2 1	6	0.2222
0 2 1 2 1 1	1	0.1667
0 2 1 2 1 2	5	0.8333
0 2 1 2 2	13	0.4815
0 2 1 2 2 0	4	0.3077
0 2 1 2 2 1	2	0.1538
0 2 1 2 2 2	7	0.5385
0 2 2	101	0.5430
0 2 2 0	15	0.1485
0 2 2 0 0	4	0.2667
0 2 2 0 0 1	1	0.2500
0 2 2 0 0 2	3	0.7500
0 2 2 0 1	3	0.2000
0 2 2 0 1 1	1	0.3333
0 2 2 0 1 2	2	0.6667
0 2 2 0 2	8	0.5333
0 2 2 0 2 0	2	0.2500
0 2 2 0 2 1	3	0.3750
0 2 2 0 2 2	3	0.3750
0 2 2 1	23	0.2277
0 2 2 1 1	14	0.6087
0 2 2 1 1 1	7	0.5000
0 2 2 1 1 2	7	0.5000
0 2 2 1 2	9	0.3913
0 2 2 1 2 0	1	0.1111
0 2 2 1 2 1	1	0.1111
0 2 2 1 2 2	7	0.7778
0 2 2 2	63	0.6238
0 2 2 2 0	13	0.2063
0 2 2 2 0 1	5	0.3846
0 2 2 2 0 2	8	0.6154
0 2 2 2 1	21	0.3333
0 2 2 2 1 1	8	0.3810
0 2 2 2 1 2	13	0.6190

0 2 2 2 2	29	0.4603
0 2 2 2 2 0	5	0.1724
0 2 2 2 2 1	10	0.3448
0 2 2 2 2 2	14	0.4828
1	984	0.3325
1 0	3	0.0030
1 0 0	1	0.3333
1 0 0 2	1	1.0000
1 0 0 2 2	1	1.0000
1 0 0 2 2 2	1	1.0000
1 0 2	2	0.6667
1 0 2 2	2	1.0000
1 0 2 2 1	1	0.5000
1 0 2 2 1 2	1	1.0000
1 0 2 2 2	1	0.5000
1 0 2 2 2 2	1	1.0000
1 1	469	0.4766
1 1 1	236	0.5032
1 1 1 1	137	0.5805
1 1 1 1 1	81	0.5912
1 1 1 1 1 1	47	0.5802
1 1 1 1 1 2	34	0.4198
1 1 1 1 2	56	0.4088
1 1 1 1 2 0	20	0.3571
1 1 1 1 2 1	11	0.1964
1 1 1 1 2 2	24	0.4286
1 1 1 2	99	0.4195
1 1 1 2 0	35	0.3535
1 1 1 2 0 0	12	0.3429
1 1 1 2 0 1	6	0.1714
1 1 1 2 0 2	17	0.4857
1 1 1 2 1	21	0.2121
1 1 1 2 1 1	13	0.6190
1 1 1 2 1 2	8	0.3810
1 1 1 2 2	42	0.4242
1 1 1 2 2 0	5	0.1190
1 1 1 2 2 1	15	0.3571
1 1 1 2 2 2	22	0.5238
1 1 2	233	0.4968
1 1 2 0	72	0.3090
1 1 2 0 0	24	0.3333
1 1 2 0 0 0	4	0.1667
1 1 2 0 0 1	11	0.4583
1 1 2 0 0 2	9	0.3750
1 1 2 0 1	18	0.2500
1 1 2 0 1 1	16	0.8889
1 1 2 0 1 2	2	0.1111
1 1 2 0 2	30	0.4167
1 1 2 0 2 0	4	0.1333
1 1 2 0 2 1	10	0.3333
1 1 2 0 2 2	16	0.5333
1 1 2 1	56	0.2403
1 1 2 1 1	24	0.4286
1 1 2 1 1 1	15	0.6250
1 1 2 1 1 2	9	0.3750
1 1 2 1 2	32	0.5714
1 1 2 1 2 0	4	0.1250
1 1 2 1 2 1	7	0.2188
1 1 2 1 2 2	21	0.6563
1 1 2 2	104	0.4464

1 1 2 2 0	14	0.1346
1 1 2 2 0 0	2	0.1429
1 1 2 2 0 1	3	0.2143
1 1 2 2 0 2	9	0.6429
1 1 2 2 1	34	0.3269
1 1 2 2 1 1	16	0.4706
1 1 2 2 1 2	18	0.5294
1 1 2 2 2	56	0.5385
1 1 2 2 2 0	4	0.0714
1 1 2 2 2 1	18	0.3214
1 1 2 2 2 2	34	0.6071
1 2	512	0.5203
1 2 0	119	0.2324
1 2 0 0	38	0.3193
1 2 0 0 0	6	0.1579
1 2 0 0 0 0	1	0.1667
1 2 0 0 0 1	2	0.3333
1 2 0 0 0 2	3	0.5000
1 2 0 0 1	15	0.3947
1 2 0 0 1 1	8	0.5333
1 2 0 0 1 2	7	0.4667
1 2 0 0 2	17	0.4474
1 2 0 0 2 0	7	0.4118
1 2 0 0 2 1	4	0.2353
1 2 0 0 2 2	6	0.3529
1 2 0 1	28	0.2353
1 2 0 1 1	23	0.8214
1 2 0 1 1 1	12	0.5217
1 2 0 1 1 2	11	0.4783
1 2 0 1 2	5	0.1786
1 2 0 1 2 1	1	0.2000
1 2 0 1 2 2	4	0.8000
1 2 0 2	53	0.4454
1 2 0 2 0	9	0.1698
1 2 0 2 0 0	3	0.3333
1 2 0 2 0 1	1	0.1111
1 2 0 2 0 2	5	0.5556
1 2 0 2 1	17	0.3208
1 2 0 2 1 1	10	0.5882
1 2 0 2 1 2	7	0.4118
1 2 0 2 2	27	0.5094
1 2 0 2 2 0	5	0.1852
1 2 0 2 2 1	6	0.2222
1 2 0 2 2 2	16	0.5926
1 2 1	113	0.2207
1 2 1 0	2	0.0177
1 2 1 0 2	2	1.0000
1 2 1 0 2 2	2	1.0000
1 2 1 1	44	0.3894
1 2 1 1 1	19	0.4318
1 2 1 1 1 1	10	0.5263
1 2 1 1 1 2	9	0.4737
1 2 1 1 2	25	0.5682
1 2 1 1 2 0	12	0.4800
1 2 1 1 2 1	5	0.2000
1 2 1 1 2 2	8	0.3200
1 2 1 2	67	0.5929
1 2 1 2 0	9	0.1343
1 2 1 2 0 0	3	0.3333
1 2 1 2 0 1	3	0.3333

1 2 1 2 0 2	3	0.3333
1 2 1 2 1	16	0.2388
1 2 1 2 1 1	8	0.5000
1 2 1 2 1 2	8	0.5000
1 2 1 2 2	42	0.6269
1 2 1 2 2 0	4	0.0952
1 2 1 2 2 1	11	0.2619
1 2 1 2 2 2	27	0.6429
1 2 2	279	0.5449
1 2 2 0	42	0.1505
1 2 2 0 0	8	0.1905
1 2 2 0 0 0	3	0.3750
1 2 2 0 0 2	5	0.6250
1 2 2 0 1	8	0.1905
1 2 2 0 1 1	5	0.6250
1 2 2 0 1 2	3	0.3750
1 2 2 0 2	26	0.6190
1 2 2 0 2 0	2	0.0769
1 2 2 0 2 1	9	0.3462
1 2 2 0 2 2	15	0.5769
1 2 2 1	80	0.2867
1 2 2 1 1	34	0.4250
1 2 2 1 1 1	11	0.3235
1 2 2 1 1 2	23	0.6765
1 2 2 1 2	46	0.5750
1 2 2 1 2 0	7	0.1522
1 2 2 1 2 1	12	0.2609
1 2 2 1 2 2	27	0.5870
1 2 2 2	157	0.5627
1 2 2 2 0	13	0.0828
1 2 2 2 0 1	3	0.2308
1 2 2 2 0 2	10	0.7692
1 2 2 2 1	36	0.2293
1 2 2 2 1 1	14	0.3889
1 2 2 2 1 2	22	0.6111
1 2 2 2 2	108	0.6879
1 2 2 2 2 0	10	0.0926
1 2 2 2 2 1	34	0.3148
1 2 2 2 2 2	64	0.5926
2	1632	0.5515
2 0	270	0.1654
2 0 0	57	0.2111
2 0 0 0	9	0.1579
2 0 0 0 0	2	0.2222
2 0 0 0 0 2	2	1.0000
2 0 0 0 1	3	0.3333
2 0 0 0 1 1	3	1.0000
2 0 0 0 2	4	0.4444
2 0 0 0 2 1	1	0.2500
2 0 0 0 2 2	3	0.7500
2 0 0 1	18	0.3158
2 0 0 1 1	8	0.4444
2 0 0 1 1 1	5	0.6250
2 0 0 1 1 2	3	0.3750
2 0 0 1 2	10	0.5556
2 0 0 1 2 0	1	0.1000
2 0 0 1 2 1	1	0.1000
2 0 0 1 2 2	8	0.8000
2 0 0 2	30	0.5263
2 0 0 2 0	10	0.3333

2 0 0 2 0 0	1	0.1000
2 0 0 2 0 1	2	0.2000
2 0 0 2 0 2	7	0.7000
2 0 0 2 1	4	0.1333
2 0 0 2 1 1	3	0.7500
2 0 0 2 1 2	1	0.2500
2 0 0 2 2	16	0.5333
2 0 0 2 2 0	3	0.1875
2 0 0 2 2 1	2	0.1250
2 0 0 2 2 2	11	0.6875
2 0 1	66	0.2444
2 0 1 1	43	0.6515
2 0 1 1 1	18	0.4186
2 0 1 1 1 1	13	0.7222
2 0 1 1 1 2	5	0.2778
2 0 1 1 2	25	0.5814
2 0 1 1 2 0	6	0.2400
2 0 1 1 2 1	10	0.4000
2 0 1 1 2 2	9	0.3600
2 0 1 2	23	0.3485
2 0 1 2 0	5	0.2174
2 0 1 2 0 0	3	0.6000
2 0 1 2 0 1	2	0.4000
2 0 1 2 1	2	0.0870
2 0 1 2 1 2	2	1.0000
2 0 1 2 2	16	0.6957
2 0 1 2 2 0	4	0.2500
2 0 1 2 2 1	4	0.2500
2 0 1 2 2 2	8	0.5000
2 0 2	147	0.5444
2 0 2 0	20	0.1361
2 0 2 0 0	3	0.1500
2 0 2 0 0 1	2	0.6667
2 0 2 0 0 2	1	0.3333
2 0 2 0 1	4	0.2000
2 0 2 0 1 1	1	0.2500
2 0 2 0 1 2	3	0.7500
2 0 2 0 2	13	0.6500
2 0 2 0 2 0	1	0.0769
2 0 2 0 2 1	5	0.3846
2 0 2 0 2 2	7	0.5385
2 0 2 1	50	0.3401
2 0 2 1 0	1	0.0200
2 0 2 1 0 0	1	1.0000
2 0 2 1 1	23	0.4600
2 0 2 1 1 1	13	0.5652
2 0 2 1 1 2	10	0.4348
2 0 2 1 2	26	0.5200
2 0 2 1 2 0	7	0.2692
2 0 2 1 2 1	6	0.2308
2 0 2 1 2 2	13	0.5000
2 0 2 2	77	0.5238
2 0 2 2 0	12	0.1558
2 0 2 2 0 0	3	0.2500
2 0 2 2 0 1	2	0.1667
2 0 2 2 0 2	7	0.5833
2 0 2 2 1	17	0.2208
2 0 2 2 1 1	11	0.6471
2 0 2 2 1 2	6	0.3529
2 0 2 2 2	48	0.6234

2 0 2 2 2 0	11	0.2292
2 0 2 2 2 1	15	0.3125
2 0 2 2 2 2	22	0.4583
2 1	428	0.2623
2 1 0	3	0.0070
2 1 0 0	1	0.3333
2 1 0 0 2	1	1.0000
2 1 0 0 2 2	1	1.0000
2 1 0 2	2	0.6667
2 1 0 2 2	2	1.0000
2 1 0 2 2 1	1	0.5000
2 1 0 2 2 2	1	0.5000
2 1 1	179	0.4182
2 1 1 1	74	0.4134
2 1 1 1 1	39	0.5270
2 1 1 1 1 1	27	0.6923
2 1 1 1 1 2	12	0.3077
2 1 1 1 2	35	0.4730
2 1 1 1 2 0	12	0.3429
2 1 1 1 2 1	9	0.2571
2 1 1 1 2 2	14	0.4000
2 1 1 2	105	0.5866
2 1 1 2 0	29	0.2762
2 1 1 2 0 0	8	0.2759
2 1 1 2 0 1	12	0.4138
2 1 1 2 0 2	9	0.3103
2 1 1 2 1	24	0.2286
2 1 1 2 1 1	8	0.3333
2 1 1 2 1 2	16	0.6667
2 1 1 2 2	52	0.4952
2 1 1 2 2 0	8	0.1538
2 1 1 2 2 1	17	0.3269
2 1 1 2 2 2	27	0.5192
2 1 2	246	0.5748
2 1 2 0	41	0.1667
2 1 2 0 0	11	0.2683
2 1 2 0 0 0	2	0.1818
2 1 2 0 0 1	2	0.1818
2 1 2 0 0 2	7	0.6364
2 1 2 0 1	7	0.1707
2 1 2 0 1 1	4	0.5714
2 1 2 0 1 2	3	0.4286
2 1 2 0 2	23	0.5610
2 1 2 0 2 0	5	0.2174
2 1 2 0 2 1	7	0.3043
2 1 2 0 2 2	11	0.4783
2 1 2 1	54	0.2195
2 1 2 1 0	2	0.0370
2 1 2 1 0 2	2	1.0000
2 1 2 1 1	20	0.3704
2 1 2 1 1 1	4	0.2000
2 1 2 1 1 2	16	0.8000
2 1 2 1 2	32	0.5926
2 1 2 1 2 0	5	0.1563
2 1 2 1 2 1	7	0.2188
2 1 2 1 2 2	20	0.6250
2 1 2 2	151	0.6138
2 1 2 2 0	22	0.1457
2 1 2 2 0 0	4	0.1818
2 1 2 2 0 1	5	0.2273

2 1 2 2 0 2	13	0.5909
2 1 2 2 1	41	0.2715
2 1 2 2 1 1	17	0.4146
2 1 2 2 1 2	24	0.5854
2 1 2 2 2	88	0.5828
2 1 2 2 2 0	8	0.0909
2 1 2 2 2 1	16	0.1818
2 1 2 2 2 2	64	0.7273
2 2	933	0.5717
2 2 0	121	0.1297
2 2 0 0	15	0.1240
2 2 0 0 0	3	0.2000
2 2 0 0 0 0	1	0.3333
2 2 0 0 0 1	1	0.3333
2 2 0 0 0 2	1	0.3333
2 2 0 0 1	1	0.0667
2 2 0 0 1 2	1	1.0000
2 2 0 0 2	11	0.7333
2 2 0 0 2 0	2	0.1818
2 2 0 0 2 2	9	0.8182
2 2 0 1	32	0.2645
2 2 0 1 1	18	0.5625
2 2 0 1 1 1	6	0.3333
2 2 0 1 1 2	12	0.6667
2 2 0 1 2	14	0.4375
2 2 0 1 2 0	3	0.2143
2 2 0 1 2 1	1	0.0714
2 2 0 1 2 2	10	0.7143
2 2 0 2	74	0.6116
2 2 0 2 0	9	0.1216
2 2 0 2 0 1	3	0.3333
2 2 0 2 0 2	6	0.6667
2 2 0 2 1	24	0.3243
2 2 0 2 1 0	1	0.0417
2 2 0 2 1 1	9	0.3750
2 2 0 2 1 2	14	0.5833
2 2 0 2 2	41	0.5541
2 2 0 2 2 0	4	0.0976
2 2 0 2 2 1	9	0.2195
2 2 0 2 2 2	28	0.6829
2 2 1	260	0.2787
2 2 1 1	108	0.4154
2 2 1 1 1	39	0.3611
2 2 1 1 1 1	20	0.5128
2 2 1 1 1 2	19	0.4872
2 2 1 1 2	69	0.6389
2 2 1 1 2 0	15	0.2174
2 2 1 1 2 1	18	0.2609
2 2 1 1 2 2	36	0.5217
2 2 1 2	152	0.5846
2 2 1 2 0	24	0.1579
2 2 1 2 0 0	6	0.2500
2 2 1 2 0 1	4	0.1667
2 2 1 2 0 2	14	0.5833
2 2 1 2 1	32	0.2105
2 2 1 2 1 0	2	0.0625
2 2 1 2 1 1	11	0.3438
2 2 1 2 1 2	19	0.5938
2 2 1 2 2	96	0.6316
2 2 1 2 2 0	14	0.1458

2 2 1 2 2 1	28	0.2917
2 2 1 2 2 2	54	0.5625
2 2 2	552	0.5916
2 2 2 0	64	0.1159
2 2 2 0 0	3	0.0469
2 2 2 0 0 2	3	1.0000
2 2 2 0 1	21	0.3281
2 2 2 0 1 1	12	0.5714
2 2 2 0 1 2	9	0.4286
2 2 2 0 2	40	0.6250
2 2 2 0 2 0	5	0.1250
2 2 2 0 2 1	12	0.3000
2 2 2 0 2 2	23	0.5750
2 2 2 1	157	0.2844
2 2 2 1 1	60	0.3822
2 2 2 1 1 1	21	0.3500
2 2 2 1 1 2	39	0.6500
2 2 2 1 2	97	0.6178
2 2 2 1 2 0	16	0.1649
2 2 2 1 2 1	19	0.1959
2 2 2 1 2 2	62	0.6392
2 2 2 2	331	0.5996
2 2 2 2 0	38	0.1148
2 2 2 2 0 0	3	0.0789
2 2 2 2 0 1	13	0.3421
2 2 2 2 0 2	22	0.5789
2 2 2 2 1	100	0.3021
2 2 2 2 1 1	38	0.3800
2 2 2 2 1 2	62	0.6200
2 2 2 2 2	193	0.5831
2 2 2 2 2 0	23	0.1192
2 2 2 2 2 1	55	0.2850
2 2 2 2 2 2	115	0.5959

FREQUENCIES AND CONDITIONAL PROBABILITIES
3 CATEGORIES

BURST (0)	REINFORCED (1)		NON-REINFORCED (2)		
0	122	0.0535	0 1 1 1	4	0.3333
0 0	13	0.1066	0 1 1 1 1	1	0.2500
0 0 1	7	0.5385	0 1 1 1 1 2	1	1.0000
0 0 1 0	1	0.1429	0 1 1 1 2	3	0.7500
0 0 1 0 2	1	1.0000	0 1 1 1 2 2	3	1.0000
0 0 1 0 2 2	1	1.0000	0 1 1 2	8	0.6667
0 0 1 1	1	0.1429	0 1 1 2 0	2	0.2500
0 0 1 1 2	1	1.0000	0 1 1 2 0 0	2	1.0000
0 0 1 1 2 1	1	1.0000	0 1 1 2 1	3	0.3750
0 0 1 2	5	0.7143	0 1 1 2 1 1	1	0.3333
0 0 1 2 2	5	1.0000	0 1 1 2 1 2	2	0.6667
0 0 1 2 2 1	3	0.6000	0 1 1 2 2	3	0.3750
0 0 1 2 2 2	2	0.4000	0 1 1 2 2 0	1	0.3333
0 0 2	6	0.4615	0 1 1 2 2 2	2	0.6667
0 0 2 1	2	0.3333	0 1 2	34	0.7234
0 0 2 1 2	2	1.0000	0 1 2 0	5	0.1471
0 0 2 1 2 2	2	1.0000	0 1 2 0 1	2	0.4000
0 0 2 2	4	0.6667	0 1 2 0 1 1	1	0.5000
0 0 2 2 0	1	0.2500	0 1 2 0 1 2	1	0.5000
0 0 2 2 0 2	1	1.0000	0 1 2 0 2	3	0.6000
0 0 2 2 1	1	0.2500	0 1 2 0 2 0	1	0.3333
0 0 2 2 1 2	1	1.0000	0 1 2 0 2 1	2	0.6667
0 0 2 2 2	2	0.5000	0 1 2 1	11	0.3235
0 0 2 2 2 2	2	1.0000	0 1 2 1 1	5	0.4545
0 1	47	0.3852	0 1 2 1 1 2	5	1.0000
0 1 0	1	0.0213	0 1 2 1 2	6	0.5455
0 1 0 2	1	1.0000	0 1 2 1 2 1	3	0.5000
0 1 0 2 2	1	1.0000	0 1 2 1 2 2	3	0.5000
0 1 0 2 2 0	1	1.0000	0 1 2 2	18	0.5294
0 1 1	12	0.2553	0 1 2 2 1	12	0.6667

0 1 2 2 1 1	1	0.0833
0 1 2 2 1 2	11	0.9167
0 1 2 2 2	6	0.3333
0 1 2 2 2 0	1	0.1667
0 1 2 2 2 1	2	0.3333
0 1 2 2 2 2	3	0.5000
0 2	62	0.5082
0 2 0	8	0.1290
0 2 0 0	1	0.1250
0 2 0 0 1	1	1.0000
0 2 0 0 1 0	1	1.0000
0 2 0 1	3	0.3750
0 2 0 1 1	1	0.3333
0 2 0 1 1 1	1	1.0000
0 2 0 1 2	2	0.6667
0 2 0 1 2 0	1	0.5000
0 2 0 1 2 1	1	0.5000
0 2 0 2	4	0.5000
0 2 0 2 0	1	0.2500
0 2 0 2 0 2	1	1.0000
0 2 0 2 1	1	0.2500
0 2 0 2 1 1	1	1.0000
0 2 0 2 2	2	0.5000
0 2 0 2 2 1	1	0.5000
0 2 0 2 2 2	1	0.5000
0 2 1	26	0.4194
0 2 1 1	5	0.1923
0 2 1 1 1	1	0.2000
0 2 1 1 1 2	1	1.0000
0 2 1 1 2	4	0.8000
0 2 1 1 2 1	2	0.5000
0 2 1 1 2 2	2	0.5000
0 2 1 2	21	0.8077
0 2 1 2 0	1	0.0476
0 2 1 2 0 2	1	1.0000
0 2 1 2 1	6	0.2857
0 2 1 2 1 1	1	0.1667
0 2 1 2 1 2	5	0.8333
0 2 1 2 2	14	0.6667
0 2 1 2 2 0	3	0.2143
0 2 1 2 2 1	1	0.0714
0 2 1 2 2 2	10	0.7143
0 2 2	28	0.4516
0 2 2 0	5	0.1786
0 2 2 0 1	2	0.4000
0 2 2 0 1 1	1	0.5000
0 2 2 0 1 2	1	0.5000
0 2 2 0 2	3	0.6000
0 2 2 0 2 2	3	1.0000
0 2 2 1	5	0.1786
0 2 2 1 1	2	0.4000
0 2 2 1 1 2	2	1.0000
0 2 2 1 2	3	0.6000
0 2 2 1 2 2	3	1.0000
0 2 2 2	18	0.6429
0 2 2 2 0	4	0.2222
0 2 2 2 0 1	1	0.2500
0 2 2 2 0 2	3	0.7500
0 2 2 2 1	6	0.3333
0 2 2 2 1 1	2	0.3333

0 2 2 2 1 2	4	0.6667
0 2 2 2 2	8	0.4444
0 2 2 2 2 1	4	0.5000
0 2 2 2 2 2	4	0.5000
1	733	0.3214
1 0	2	0.0027
1 0 2	2	1.0000
1 0 2 1	1	0.5000
1 0 2 1 2	1	1.0000
1 0 2 1 2 2	1	1.0000
1 0 2 2	1	0.5000
1 0 2 2 0	1	1.0000
1 0 2 2 0 1	1	1.0000
1 1	202	0.2756
1 1 1	58	0.2871
1 1 1 1	16	0.2759
1 1 1 1 1	5	0.3125
1 1 1 1 1 1	1	0.2000
1 1 1 1 1 2	4	0.8000
1 1 1 1 2	11	0.6875
1 1 1 1 2 0	3	0.2727
1 1 1 1 2 1	3	0.2727
1 1 1 1 2 2	5	0.4545
1 1 1 2	42	0.7241
1 1 1 2 0	4	0.0952
1 1 1 2 0 1	2	0.5000
1 1 1 2 0 2	2	0.5000
1 1 1 2 1	14	0.3333
1 1 1 2 1 1	4	0.2857
1 1 1 2 1 2	10	0.7143
1 1 1 2 2	24	0.5714
1 1 1 2 2 0	1	0.0417
1 1 1 2 2 1	9	0.3750
1 1 1 2 2 2	14	0.5833
1 1 2	144	0.7129
1 1 2 0	13	0.0903
1 1 2 0 0	2	0.1538
1 1 2 0 0 1	1	0.5000
1 1 2 0 0 2	1	0.5000
1 1 2 0 1	5	0.3846
1 1 2 0 1 2	5	1.0000
1 1 2 0 2	6	0.4615
1 1 2 0 2 1	4	0.6667
1 1 2 0 2 2	2	0.3333
1 1 2 1	47	0.3264
1 1 2 1 1	16	0.3404
1 1 2 1 1 1	5	0.3125
1 1 2 1 1 2	11	0.6875
1 1 2 1 2	31	0.6596
1 1 2 1 2 0	4	0.1290
1 1 2 1 2 1	9	0.2903
1 1 2 1 2 2	18	0.5806
1 1 2 2	84	0.5833
1 1 2 2 0	6	0.0714
1 1 2 2 0 1	3	0.5000
1 1 2 2 0 2	3	0.5000
1 1 2 2 1	33	0.3929
1 1 2 2 1 1	10	0.3030
1 1 2 2 1 2	23	0.6970
1 1 2 2 2	45	0.5357
1 1 2 2 2 0	2	0.0444
1 1 2 2 2 1	18	0.4000

1 1 2 2 2 2	24	0.5333
1 2	529	0.7217
1 2 0	44	0.0832
1 2 0 0	7	0.1591
1 2 0 0 1	5	0.7143
1 2 0 0 1 1	1	0.2000
1 2 0 0 1 2	4	0.8000
1 2 0 0 2	2	0.2857
1 2 0 0 2 1	1	0.5000
1 2 0 0 2 2	1	0.5000
1 2 0 1	15	0.3409
1 2 0 1 1	2	0.1333
1 2 0 1 1 1	2	1.0000
1 2 0 1 2	13	0.8667
1 2 0 1 2 0	4	0.3077
1 2 0 1 2 1	5	0.3846
1 2 0 1 2 2	4	0.3077
1 2 0 2	22	0.5000
1 2 0 2 0	4	0.1818
1 2 0 2 0 0	1	0.2500
1 2 0 2 0 1	1	0.2500
1 2 0 2 0 2	2	0.5000
1 2 0 2 1	12	0.5455
1 2 0 2 1 1	3	0.2500
1 2 0 2 1 2	9	0.7500
1 2 0 2 2	6	0.2727
1 2 0 2 2 1	2	0.3333
1 2 0 2 2 2	4	0.6667
1 2 1	173	0.3270
1 2 1 1	59	0.3410
1 2 1 1 1	13	0.2203
1 2 1 1 1 1	3	0.2308
1 2 1 1 1 2	10	0.7692
1 2 1 1 2	46	0.7797
1 2 1 1 2 0	5	0.1087
1 2 1 1 2 1	12	0.2609
1 2 1 1 2 2	29	0.6304
1 2 1 2	114	0.6590
1 2 1 2 0	11	0.0965
1 2 1 2 0 0	4	0.3636
1 2 1 2 0 1	4	0.3636
1 2 1 2 0 2	3	0.2727
1 2 1 2 1	41	0.3596
1 2 1 2 1 1	13	0.3171
1 2 1 2 1 2	28	0.6829
1 2 1 2 2	62	0.5439
1 2 1 2 2 0	5	0.0806
1 2 1 2 2 1	24	0.3871
1 2 1 2 2 2	33	0.5323
1 2 2	312	0.5898
1 2 2 0	21	0.0673
1 2 2 0 0	1	0.0476
1 2 2 0 0 1	1	1.0000
1 2 2 0 1	8	0.3810
1 2 2 0 1 1	3	0.3750
1 2 2 0 1 2	5	0.6250
1 2 2 0 2	12	0.5714
1 2 2 0 2 0	2	0.1667
1 2 2 0 2 1	5	0.4167
1 2 2 0 2 2	5	0.4167

1 2 2 1	115	0.3686
1 2 2 1 1	32	0.2783
1 2 2 1 1 1	9	0.2812
1 2 2 1 1 2	23	0.7188
1 2 2 1 2	83	0.7217
1 2 2 1 2 0	7	0.0843
1 2 2 1 2 1	32	0.3855
1 2 2 1 2 2	44	0.5301
1 2 2 2	176	0.5641
1 2 2 2 0	9	0.0511
1 2 2 2 0 1	6	0.6667
1 2 2 2 0 2	3	0.3333
1 2 2 2 1	67	0.3807
1 2 2 2 1 0	1	0.0149
1 2 2 2 1 1	15	0.2239
1 2 2 2 1 2	51	0.7612
1 2 2 2 2	99	0.5625
1 2 2 2 2 0	3	0.0303
1 2 2 2 2 1	29	0.2929
1 2 2 2 2 2	67	0.6768
2	1425	0.6247
2 0	107	0.0751
2 0 0	13	0.1215
2 0 0 1	7	0.5385
2 0 0 1 0	1	0.1429
2 0 0 1 0 2	1	1.0000
2 0 0 1 1	1	0.1429
2 0 0 1 1 2	1	1.0000
2 0 0 1 2	5	0.7143
2 0 0 1 2 2	5	1.0000
2 0 0 2	6	0.4615
2 0 0 2 1	2	0.3333
2 0 0 2 1 2	2	1.0000
2 0 0 2 2	4	0.6667
2 0 0 2 2 0	1	0.2500
2 0 0 2 2 1	1	0.2500
2 0 0 2 2 2	2	0.5000
2 0 1	40	0.3738
2 0 1 1	11	0.2750
2 0 1 1 1	4	0.3636
2 0 1 1 1 1	1	0.2500
2 0 1 1 1 2	3	0.7500
2 0 1 1 2	7	0.6364
2 0 1 1 2 0	2	0.2857
2 0 1 1 2 1	2	0.2857
2 0 1 1 2 2	3	0.4286
2 0 1 2	29	0.7250
2 0 1 2 0	5	0.1724
2 0 1 2 0 1	2	0.4000
2 0 1 2 0 2	3	0.6000
2 0 1 2 1	11	0.3793
2 0 1 2 1 1	5	0.4545
2 0 1 2 1 2	6	0.5455
2 0 1 2 2	13	0.4483
2 0 1 2 2 1	9	0.6923
2 0 1 2 2 2	4	0.3077
2 0 2	54	0.5047
2 0 2 0	8	0.1481
2 0 2 0 0	1	0.1250
2 0 2 0 0 1	1	1.0000

2 0 2 0 1	3	0.3750
2 0 2 0 1 1	1	0.3333
2 0 2 0 1 2	2	0.6667
2 0 2 0 2	4	0.5000
2 0 2 0 2 0	1	0.2500
2 0 2 0 2 1	1	0.2500
2 0 2 0 2 2	2	0.5000
2 0 2 1	23	0.4259
2 0 2 1 1	5	0.2174
2 0 2 1 1 1	1	0.2000
2 0 2 1 1 2	4	0.8000
2 0 2 1 2	18	0.7826
2 0 2 1 2 0	1	0.0556
2 0 2 1 2 1	6	0.3333
2 0 2 1 2 2	11	0.6111
2 0 2 2	23	0.4259
2 0 2 2 0	3	0.1304
2 0 2 2 0 1	1	0.3333
2 0 2 2 0 2	2	0.6667
2 0 2 2 1	4	0.1739
2 0 2 2 1 1	2	0.5000
2 0 2 2 1 2	2	0.5000
2 0 2 2 2	16	0.6957
2 0 2 2 2 0	4	0.2500
2 0 2 2 2 1	6	0.3750
2 0 2 2 2 2	6	0.3750
2 1	484	0.3396
2 1 0	1	0.0021
2 1 0 2	1	1.0000
2 1 0 2 1	1	1.0000
2 1 0 2 1 2	1	1.0000
2 1 1	132	0.2727
2 1 1 1	38	0.2879
2 1 1 1 1	10	0.2632
2 1 1 1 1 1	4	0.4000
2 1 1 1 1 2	6	0.6000
2 1 1 1 2	28	0.7368
2 1 1 1 2 0	1	0.0357
2 1 1 1 2 1	11	0.3929
2 1 1 1 2 2	16	0.5714
2 1 1 2	94	0.7121
2 1 1 2 0	7	0.0745
2 1 1 2 0 1	3	0.4286
2 1 1 2 0 2	4	0.5714
2 1 1 2 1	30	0.3191
2 1 1 2 1 1	11	0.3667
2 1 1 2 1 2	19	0.6333
2 1 1 2 2	57	0.6064
2 1 1 2 2 0	4	0.0702
2 1 1 2 2 1	24	0.4211
2 1 1 2 2 2	29	0.5088
2 1 2	351	0.7252
2 1 2 0	26	0.0741
2 1 2 0 0	5	0.1923
2 1 2 0 0 1	4	0.8000
2 1 2 0 0 2	1	0.2000
2 1 2 0 1	8	0.3077
2 1 2 0 1 1	1	0.1250
2 1 2 0 1 2	7	0.8750
2 1 2 0 2	13	0.5000

2 1 2 0 2 0	3	0.2308
2 1 2 0 2 1	6	0.4615
2 1 2 0 2 2	4	0.3077
2 1 2 1	115	0.3276
2 1 2 1 1	38	0.3304
2 1 2 1 1 1	8	0.2105
2 1 2 1 1 2	30	0.7895
2 1 2 1 2	77	0.6696
2 1 2 1 2 0	7	0.0909
2 1 2 1 2 1	29	0.3766
2 1 2 1 2 2	41	0.5325
2 1 2 2	210	0.5983
2 1 2 2 0	15	0.0714
2 1 2 2 0 0	1	0.0667
2 1 2 2 0 1	5	0.3333
2 1 2 2 0 2	9	0.6000
2 1 2 2 1	70	0.3333
2 1 2 2 1 1	21	0.3000
2 1 2 2 1 2	49	0.7000
2 1 2 2 2	125	0.5952
2 1 2 2 2 0	6	0.0480
2 1 2 2 2 1	47	0.3760
2 1 2 2 2 2	72	0.5760
2 2	833	0.5846
2 2 0	55	0.0660
2 2 0 0	5	0.0909
2 2 0 0 1	1	0.2000
2 2 0 0 1 2	1	1.0000
2 2 0 0 2	4	0.8000
2 2 0 0 2 1	1	0.2500
2 2 0 0 2 2	3	0.7500
2 2 0 1	22	0.4000
2 2 0 1 1	8	0.3636
2 2 0 1 1 1	1	0.1250
2 2 0 1 1 2	7	0.8750
2 2 0 1 2	14	0.6364
2 2 0 1 2 1	5	0.3571
2 2 0 1 2 2	9	0.6429
2 2 0 2	28	0.5091
2 2 0 2 0	3	0.1071
2 2 0 2 0 1	2	0.6667
2 2 0 2 0 2	1	0.3333
2 2 0 2 1	10	0.3571
2 2 0 2 1 1	1	0.1000
2 2 0 2 1 2	9	0.9000
2 2 0 2 2	15	0.5357
2 2 0 2 2 0	3	0.2000
2 2 0 2 2 1	1	0.0667
2 2 0 2 2 2	11	0.7333
2 2 1	285	0.3421
2 2 1 0	1	0.0035
2 2 1 0 2	1	1.0000
2 2 1 0 2 1	1	1.0000
2 2 1 1	68	0.2386
2 2 1 1 1	24	0.3529
2 2 1 1 1 1	7	0.2917
2 2 1 1 1 2	17	0.7083
2 2 1 1 2	44	0.6471
2 2 1 1 2 0	2	0.0455
2 2 1 1 2 1	16	0.3636

2 2 1 1 2 2	26	0.5909
2 2 1 2	216	0.7579
2 2 1 2 0	14	0.0648
2 2 1 2 0 0	1	0.0714
2 2 1 2 0 1	4	0.2857
2 2 1 2 0 2	9	0.6429
2 2 1 2 1	68	0.3148
2 2 1 2 1 1	24	0.3529
2 2 1 2 1 2	44	0.6471
2 2 1 2 2	134	0.6204
2 2 1 2 2 0	7	0.0522
2 2 1 2 2 1	45	0.3358
2 2 1 2 2 2	82	0.6119
2 2 2	492	0.5906
2 2 2 0	29	0.0589
2 2 2 0 0	4	0.1379
2 2 2 0 0 2	4	1.0000
2 2 2 0 1	12	0.4138
2 2 2 0 1 1	4	0.3333
2 2 2 0 1 2	8	0.6667
2 2 2 0 2	13	0.4483
2 2 2 0 2 0	1	0.0769
2 2 2 0 2 1	5	0.3846
2 2 2 0 2 2	7	0.5385
2 2 2 1	165	0.3354
2 2 2 1 0	1	0.0061
2 2 2 1 0 2	1	1.0000
2 2 2 1 1	34	0.2061
2 2 2 1 1 1	15	0.4412
2 2 2 1 1 2	19	0.5588
2 2 2 1 2	130	0.7879
2 2 2 1 2 0	7	0.0538
2 2 2 1 2 1	36	0.2769
2 2 2 1 2 2	87	0.6692
2 2 2 2	297	0.6037
2 2 2 2 0	16	0.0539
2 2 2 2 0 0	4	0.2500
2 2 2 2 0 1	5	0.3125
2 2 2 2 0 2	7	0.4375
2 2 2 2 1	92	0.3098
2 2 2 2 1 1	17	0.1848
2 2 2 2 1 2	75	0.8152
2 2 2 2 2	189	0.6364
2 2 2 2 2 0	13	0.0688
2 2 2 2 2 1	59	0.3122
2 2 2 2 2 2	117	0.6190

FREQUENCIES AND CONDITIONAL PROBABILITIES
3 CATEGORIES

BURST (0)	REINFORCED (1)		NON-REINFORCED (2)		
0	378	0.1469	0 0 1 2 0 0	1	0.3333
0 0	77	0.2037	0 0 1 2 0 1	1	0.3333
0 0 0	11	0.1429	0 0 1 2 0 2	1	0.3333
0 0 0 0	3	0.2727	0 0 1 2 1	2	0.2222
0 0 0 0 0	1	0.3333	0 0 1 2 1 1	1	0.5000
0 0 0 0 0 2	1	1.0000	0 0 1 2 1 2	1	0.5000
0 0 0 0 2	2	0.6667	0 0 1 2 2	4	0.4444
0 0 0 0 2 2	2	1.0000	0 0 1 2 2 0	1	0.2500
0 0 0 1	2	0.1818	0 0 1 2 2 1	1	0.2500
0 0 0 1 1	1	0.5000	0 0 1 2 2 2	2	0.5000
0 0 0 1 1 2	1	1.0000	0 0 2	46	0.5974
0 0 0 1 2	1	0.5000	0 0 2 0	15	0.3261
0 0 0 1 2 2	1	1.0000	0 0 2 0 0	5	0.3333
0 0 0 2	6	0.5455	0 0 2 0 0 0	1	0.2000
0 0 0 2 0	3	0.5000	0 0 2 0 0 2	4	0.8000
0 0 0 2 0 1	1	0.3333	0 0 2 0 1	3	0.2000
0 0 0 2 0 2	2	0.6667	0 0 2 0 1 1	1	0.3333
0 0 0 2 2	3	0.5000	0 0 2 0 1 2	2	0.6667
0 0 0 2 2 0	2	0.6667	0 0 2 0 2	7	0.4667
0 0 0 2 2 2	1	0.3333	0 0 2 0 2 0	1	0.1429
0 0 1	20	0.2597	0 0 2 0 2 1	1	0.1429
0 0 1 1	11	0.5500	0 0 2 0 2 2	5	0.7143
0 0 1 1 1	5	0.4545	0 0 2 1	6	0.1304
0 0 1 1 1 1	1	0.2000	0 0 2 1 1	3	0.5000
0 0 1 1 1 2	4	0.8000	0 0 2 1 1 1	2	0.6667
0 0 1 1 2	6	0.5455	0 0 2 1 1 2	1	0.3333
0 0 1 1 2 0	2	0.3333	0 0 2 1 2	3	0.5000
0 0 1 1 2 2	4	0.6667	0 0 2 1 2 0	2	0.6667
0 0 1 2	9	0.4500	0 0 2 1 2 2	1	0.3333
0 0 1 2 0	3	0.3333	0 0 2 2	25	0.5435

0 0 2 2 0	6	0.2400
0 0 2 2 0 0	1	0.1667
0 0 2 2 0 1	1	0.1667
0 0 2 2 0 2	4	0.6667
0 0 2 2 1	2	0.0800
0 0 2 2 1 2	2	1.0000
0 0 2 2 2	17	0.6800
0 0 2 2 2 0	5	0.2941
0 0 2 2 2 1	1	0.0588
0 0 2 2 2 2	11	0.6471
0 1	84	0.2222
0 1 1	40	0.4762
0 1 1 0	2	0.0500
0 1 1 0 0	1	0.5000
0 1 1 0 0 1	1	1.0000
0 1 1 0 2	1	0.5000
0 1 1 0 2 0	1	1.0000
0 1 1 1	18	0.4500
0 1 1 1 1	12	0.6667
0 1 1 1 1 1	10	0.8333
0 1 1 1 1 2	2	0.1667
0 1 1 1 2	6	0.3333
0 1 1 1 2 0	2	0.3333
0 1 1 1 2 1	2	0.3333
0 1 1 1 2 2	2	0.3333
0 1 1 2	20	0.5000
0 1 1 2 0	9	0.4500
0 1 1 2 0 0	4	0.4444
0 1 1 2 0 1	1	0.1111
0 1 1 2 0 2	4	0.4444
0 1 1 2 1	2	0.1000
0 1 1 2 1 1	2	1.0000
0 1 1 2 2	9	0.4500
0 1 1 2 2 0	3	0.3333
0 1 1 2 2 2	6	0.6667
0 1 2	44	0.5238
0 1 2 0	16	0.3636
0 1 2 0 0	4	0.2500
0 1 2 0 0 1	1	0.2500
0 1 2 0 0 2	3	0.7500
0 1 2 0 1	4	0.2500
0 1 2 0 1 1	2	0.5000
0 1 2 0 1 2	2	0.5000
0 1 2 0 2	8	0.5000
0 1 2 0 2 0	1	0.1250
0 1 2 0 2 1	2	0.2500
0 1 2 0 2 2	5	0.6250
0 1 2 1	6	0.1364
0 1 2 1 1	3	0.5000
0 1 2 1 1 1	2	0.6667
0 1 2 1 1 2	1	0.3333
0 1 2 1 2	3	0.5000
0 1 2 1 2 0	2	0.6667
0 1 2 1 2 1	1	0.3333
0 1 2 2	22	0.5000
0 1 2 2 0	4	0.1818
0 1 2 2 0 0	1	0.2500
0 1 2 2 0 2	3	0.7500
0 1 2 2 1	5	0.2273
0 1 2 2 1 1	1	0.2000

0 1 2 2 1 2	4	0.8000
0 1 2 2 2	13	0.5909
0 1 2 2 2 0	2	0.1538
0 1 2 2 2 1	5	0.3846
0 1 2 2 2 2	6	0.4615
0 2	217	0.5741
0 2 0	46	0.2120
0 2 0 0	13	0.2826
0 2 0 0 0	2	0.1538
0 2 0 0 0 0	1	0.5000
0 2 0 0 0 2	1	0.5000
0 2 0 0 1	4	0.3077
0 2 0 0 1 1	3	0.7500
0 2 0 0 1 2	1	0.2500
0 2 0 0 2	7	0.5385
0 2 0 0 2 0	2	0.2857
0 2 0 0 2 1	1	0.1429
0 2 0 0 2 2	4	0.5714
0 2 0 1	5	0.1087
0 2 0 1 1	1	0.2000
0 2 0 1 1 1	1	1.0000
0 2 0 1 2	4	0.8000
0 2 0 1 2 0	1	0.2500
0 2 0 1 2 1	1	0.2500
0 2 0 1 2 2	2	0.5000
0 2 0 2	28	0.6087
0 2 0 2 0	6	0.2143
0 2 0 2 0 2	6	1.0000
0 2 0 2 1	5	0.1786
0 2 0 2 1 1	2	0.4000
0 2 0 2 1 2	3	0.6000
0 2 0 2 2	17	0.6071
0 2 0 2 2 0	6	0.3529
0 2 0 2 2 1	3	0.1765
0 2 0 2 2 2	8	0.4706
0 2 1	40	0.1843
0 2 1 1	16	0.4000
0 2 1 1 1	8	0.5000
0 2 1 1 1 1	6	0.7500
0 2 1 1 1 2	2	0.2500
0 2 1 1 2	8	0.5000
0 2 1 1 2 0	4	0.5000
0 2 1 1 2 2	4	0.5000
0 2 1 2	24	0.6000
0 2 1 2 0	14	0.5833
0 2 1 2 0 0	6	0.4286
0 2 1 2 0 1	6	0.4286
0 2 1 2 0 2	2	0.1429
0 2 1 2 1	3	0.1250
0 2 1 2 1 2	3	1.0000
0 2 1 2 2	7	0.2917
0 2 1 2 2 1	4	0.5714
0 2 1 2 2 2	3	0.4286
0 2 2	131	0.6037
0 2 2 0	25	0.1908
0 2 2 0 0	3	0.1200
0 2 2 0 0 1	1	0.3333
0 2 2 0 0 2	2	0.6667
0 2 2 0 1	6	0.2400
0 2 2 0 1 1	1	0.1667

0 2 2 0 1 2	5	0.8333
0 2 2 0 2	16	0.6400
0 2 2 0 2 0	6	0.3750
0 2 2 0 2 1	4	0.2500
0 2 2 0 2 2	6	0.3750
0 2 2 1	21	0.1603
0 2 2 1 1	12	0.5714
0 2 2 1 1 0	1	0.0833
0 2 2 1 1 1	3	0.2500
0 2 2 1 1 2	8	0.6667
0 2 2 1 2	9	0.4286
0 2 2 1 2 0	1	0.1111
0 2 2 1 2 1	4	0.4444
0 2 2 1 2 2	4	0.4444
0 2 2 2	84	0.6412
0 2 2 2 0	14	0.1667
0 2 2 2 0 0	3	0.2143
0 2 2 2 0 1	6	0.4286
0 2 2 2 0 2	5	0.3571
0 2 2 2 1	14	0.1667
0 2 2 2 1 1	8	0.5714
0 2 2 2 1 2	6	0.4286
0 2 2 2 2	56	0.6667
0 2 2 2 2 0	12	0.2143
0 2 2 2 2 1	12	0.2143
0 2 2 2 2 2	32	0.5714
1	832	0.3234
1 0	7	0.0084
1 0 0	2	0.2857
1 0 0 0	1	0.5000
1 0 0 0 1	1	1.0000
1 0 0 0 1 2	1	1.0000
1 0 0 1	1	0.5000
1 0 0 1 1	1	1.0000
1 0 0 1 1 2	1	1.0000
1 0 1	1	0.1429
1 0 1 1	1	1.0000
1 0 1 1 2	1	1.0000
1 0 1 1 2 1	1	1.0000
1 0 2	4	0.5714
1 0 2 0	1	0.2500
1 0 2 0 0	1	1.0000
1 0 2 0 0 1	1	1.0000
1 0 2 2	3	0.7500
1 0 2 2 1	1	0.3333
1 0 2 2 1 2	1	1.0000
1 0 2 2 2	2	0.6667
1 0 2 2 2 2	2	1.0000
1 1	450	0.5409
1 1 0	6	0.0133
1 1 0 0	2	0.3333
1 1 0 0 0	1	0.5000
1 1 0 0 0 1	1	1.0000
1 1 0 0 1	1	0.5000
1 1 0 0 1 1	1	1.0000
1 1 0 1	1	0.1667
1 1 0 1 1	1	1.0000
1 1 0 1 1 2	1	1.0000
1 1 0 2	3	0.5000
1 1 0 2 0	1	0.3333

1 1 0 2 0 0	1	1.0000
1 1 0 2 2	2	0.6667
1 1 0 2 2 1	1	0.5000
1 1 0 2 2 2	1	0.5000
1 1 1	266	0.5911
1 1 1 0	1	0.0038
1 1 1 0 0	1	1.0000
1 1 1 0 0 0	1	1.0000
1 1 1 1	192	0.7218
1 1 1 1 0	1	0.0052
1 1 1 1 0 0	1	1.0000
1 1 1 1 1	138	0.7188
1 1 1 1 1 0	1	0.0072
1 1 1 1 1 1	92	0.6667
1 1 1 1 1 2	45	0.3261
1 1 1 1 2	53	0.2760
1 1 1 1 2 0	21	0.3962
1 1 1 1 2 1	10	0.1887
1 1 1 1 2 2	22	0.4151
1 1 1 2	73	0.2744
1 1 1 2 0	29	0.3973
1 1 1 2 0 0	6	0.2069
1 1 1 2 0 1	8	0.2759
1 1 1 2 0 2	15	0.5172
1 1 1 2 1	14	0.1918
1 1 1 2 1 1	9	0.6429
1 1 1 2 1 2	5	0.3571
1 1 1 2 2	30	0.4110
1 1 1 2 2 0	5	0.1667
1 1 1 2 2 1	7	0.2333
1 1 1 2 2 2	18	0.6000
1 1 2	178	0.3956
1 1 2 0	76	0.4270
1 1 2 0 0	15	0.1974
1 1 2 0 0 0	1	0.0667
1 1 2 0 0 1	3	0.2000
1 1 2 0 0 2	11	0.7333
1 1 2 0 1	17	0.2237
1 1 2 0 1 1	9	0.5294
1 1 2 0 1 2	8	0.4706
1 1 2 0 2	44	0.5789
1 1 2 0 2 0	7	0.1591
1 1 2 0 2 1	8	0.1818
1 1 2 0 2 2	29	0.6591
1 1 2 1	26	0.1461
1 1 2 1 1	15	0.5769
1 1 2 1 1 1	12	0.8000
1 1 2 1 1 2	3	0.2000
1 1 2 1 2	11	0.4231
1 1 2 1 2 0	6	0.5455
1 1 2 1 2 1	1	0.0909
1 1 2 1 2 2	4	0.3636
1 1 2 2	76	0.4270
1 1 2 2 0	17	0.2237
1 1 2 2 0 0	6	0.3529
1 1 2 2 0 1	3	0.1765
1 1 2 2 0 2	8	0.4706
1 1 2 2 1	16	0.2105
1 1 2 2 1 0	1	0.0625
1 1 2 2 1 1	7	0.4375

1 1 2 2 1 2	8	0.5000
1 1 2 2 2	43	0.5658
1 1 2 2 2 0	5	0.1163
1 1 2 2 2 1	14	0.3256
1 1 2 2 2 2	24	0.5581
1 2	375	0.4507
1 2 0	133	0.3547
1 2 0 0	31	0.2331
1 2 0 0 0	1	0.0323
1 2 0 0 0 0	1	1.0000
1 2 0 0 1	8	0.2581
1 2 0 0 1 1	3	0.3750
1 2 0 0 1 2	5	0.6250
1 2 0 0 2	22	0.7097
1 2 0 0 2 0	6	0.2727
1 2 0 0 2 1	3	0.1364
1 2 0 0 2 2	13	0.5909
1 2 0 1	33	0.2481
1 2 0 1 1	18	0.5455
1 2 0 1 1 1	8	0.4444
1 2 0 1 1 2	10	0.5556
1 2 0 1 2	15	0.4545
1 2 0 1 2 0	7	0.4667
1 2 0 1 2 1	2	0.1333
1 2 0 1 2 2	6	0.4000
1 2 0 2	69	0.5188
1 2 0 2 0	9	0.1304
1 2 0 2 0 0	2	0.2222
1 2 0 2 0 2	7	0.7778
1 2 0 2 1	14	0.2029
1 2 0 2 1 1	7	0.5000
1 2 0 2 1 2	7	0.5000
1 2 0 2 2	46	0.6667
1 2 0 2 2 0	5	0.1087
1 2 0 2 2 1	10	0.2174
1 2 0 2 2 2	31	0.6739
1 2 1	70	0.1867
1 2 1 1	33	0.4714
1 2 1 1 1	19	0.5758
1 2 1 1 1 1	15	0.7895
1 2 1 1 1 2	4	0.2105
1 2 1 1 2	14	0.4242
1 2 1 1 2 0	5	0.3571
1 2 1 1 2 1	3	0.2143
1 2 1 1 2 2	6	0.4286
1 2 1 2	37	0.5286
1 2 1 2 0	13	0.3514
1 2 1 2 0 0	2	0.1538
1 2 1 2 0 1	3	0.2308
1 2 1 2 0 2	8	0.6154
1 2 1 2 1	6	0.1622
1 2 1 2 1 1	2	0.3333
1 2 1 2 1 2	4	0.6667
1 2 1 2 2	18	0.4865
1 2 1 2 2 0	1	0.0556
1 2 1 2 2 1	8	0.4444
1 2 1 2 2 2	9	0.5000
1 2 2	172	0.4587
1 2 2 0	27	0.1570
1 2 2 0 0	8	0.2963

1 2 2 0 0 0	3	0.3750
1 2 2 0 0 1	3	0.3750
1 2 2 0 0 2	2	0.2500
1 2 2 0 1	4	0.1481
1 2 2 0 1 1	4	1.0000
1 2 2 0 2	15	0.5556
1 2 2 0 2 0	3	0.2000
1 2 2 0 2 1	5	0.3333
1 2 2 0 2 2	7	0.4667
1 2 2 1	50	0.2907
1 2 2 1 0	1	0.0200
1 2 2 1 0 2	1	1.0000
1 2 2 1 1	22	0.4400
1 2 2 1 1 1	8	0.3636
1 2 2 1 1 2	14	0.6364
1 2 2 1 2	27	0.5400
1 2 2 1 2 0	3	0.1111
1 2 2 1 2 1	6	0.2222
1 2 2 1 2 2	18	0.6667
1 2 2 2	95	0.5523
1 2 2 2 0	10	0.1053
1 2 2 2 0 0	1	0.1000
1 2 2 2 0 1	4	0.4000
1 2 2 2 0 2	5	0.5000
1 2 2 2 1	29	0.3053
1 2 2 2 1 1	13	0.4483
1 2 2 2 1 2	16	0.5517
1 2 2 2 2	56	0.5895
1 2 2 2 2 0	8	0.1429
1 2 2 2 2 1	18	0.3214
1 2 2 2 2 2	30	0.5357
2	1362	0.5293
2 0	294	0.2159
2 0 0	64	0.2177
2 0 0 0	7	0.1094
2 0 0 0 0	2	0.2857
2 0 0 0 0 0	1	0.5000
2 0 0 0 0 0 2	1	0.5000
2 0 0 0 1	1	0.1429
2 0 0 0 1 1	1	1.0000
2 0 0 0 2	4	0.5714
2 0 0 0 2 0	3	0.7500
2 0 0 0 2 2	1	0.2500
2 0 0 1	17	0.2656
2 0 0 1 1	9	0.5294
2 0 0 1 1 1	5	0.5556
2 0 0 1 1 2	4	0.4444
2 0 0 1 2	8	0.4706
2 0 0 1 2 0	3	0.3750
2 0 0 1 2 1	2	0.2500
2 0 0 1 2 2	3	0.3750
2 0 0 2	40	0.6250
2 0 0 2 0	12	0.3000
2 0 0 2 0 0	5	0.4167
2 0 0 2 0 1	2	0.1667
2 0 0 2 0 2	5	0.4167
2 0 0 2 1	6	0.1500
2 0 0 2 1 1	3	0.5000
2 0 0 2 1 2	3	0.5000
2 0 0 2 2	22	0.5500

2 0 0 2 2 0	4	0.1818
2 0 0 2 2 1	2	0.0909
2 0 0 2 2 2	16	0.7273
2 0 1	63	0.2143
2 0 1 1	28	0.4444
2 0 1 1 0	2	0.0714
2 0 1 1 0 0	1	0.5000
2 0 1 1 0 2	1	0.5000
2 0 1 1 1	13	0.4643
2 0 1 1 1 1	11	0.8462
2 0 1 1 1 2	2	0.1538
2 0 1 1 2	13	0.4643
2 0 1 1 2 0	7	0.5385
2 0 1 1 2 1	1	0.0769
2 0 1 1 2 2	5	0.3846
2 0 1 2	35	0.5556
2 0 1 2 0	13	0.3714
2 0 1 2 0 0	3	0.2308
2 0 1 2 0 1	3	0.2308
2 0 1 2 0 2	7	0.5385
2 0 1 2 1	4	0.1143
2 0 1 2 1 1	2	0.5000
2 0 1 2 1 2	2	0.5000
2 0 1 2 2	18	0.5143
2 0 1 2 2 0	3	0.1667
2 0 1 2 2 1	4	0.2222
2 0 1 2 2 2	11	0.6111
2 0 2	167	0.5680
2 0 2 0	30	0.1796
2 0 2 0 0	7	0.2333
2 0 2 0 0 0	1	0.1429
2 0 2 0 0 1	3	0.4286
2 0 2 0 0 2	3	0.4286
2 0 2 0 1	2	0.0667
2 0 2 0 1 2	2	1.0000
2 0 2 0 2	21	0.7000
2 0 2 0 2 0	5	0.2381
2 0 2 0 2 1	4	0.1905
2 0 2 0 2 2	12	0.5714
2 0 2 1	34	0.2036
2 0 2 1 1	13	0.3824
2 0 2 1 1 1	6	0.4615
2 0 2 1 1 2	7	0.5385
2 0 2 1 2	21	0.6176
2 0 2 1 2 0	12	0.5714
2 0 2 1 2 1	3	0.1429
2 0 2 1 2 2	6	0.2857
2 0 2 2	103	0.6168
2 0 2 2 0	19	0.1845
2 0 2 2 0 0	2	0.1053
2 0 2 2 0 1	5	0.2632
2 0 2 2 0 2	12	0.6316
2 0 2 2 1	18	0.1748
2 0 2 2 1 1	12	0.6667
2 0 2 2 1 2	6	0.3333
2 0 2 2 2	65	0.6311
2 0 2 2 2 0	9	0.1385
2 0 2 2 2 1	13	0.2000
2 0 2 2 2 2	43	0.6615
2 1	298	0.2188

2 1 0	1	0.0034
2 1 0 2	1	1.0000
2 1 0 2 2	1	1.0000
2 1 0 2 2 2	1	1.0000
2 1 1	144	0.4832
2 1 1 0	3	0.0208
2 1 1 0 1	1	0.3333
2 1 1 0 1 1	1	1.0000
2 1 1 0 2	2	0.6667
2 1 1 0 2 2	2	1.0000
2 1 1 1	56	0.3889
2 1 1 1 1	42	0.7500
2 1 1 1 1 1	36	0.8571
2 1 1 1 1 2	6	0.1429
2 1 1 1 2	14	0.2500
2 1 1 1 2 0	6	0.4286
2 1 1 1 2 1	2	0.1429
2 1 1 1 2 2	6	0.4286
2 1 1 2	85	0.5903
2 1 1 2 0	38	0.4471
2 1 1 2 0 0	5	0.1316
2 1 1 2 0 1	8	0.2105
2 1 1 2 0 2	25	0.6579
2 1 1 2 1	10	0.1176
2 1 1 2 1 1	4	0.4000
2 1 1 2 1 2	6	0.6000
2 1 1 2 2	37	0.4353
2 1 1 2 2 0	9	0.2432
2 1 1 2 2 1	9	0.2432
2 1 1 2 2 2	19	0.5135
2 1 2	153	0.5134
2 1 2 0	41	0.2680
2 1 2 0 0	12	0.2927
2 1 2 0 0 1	4	0.3333
2 1 2 0 0 2	8	0.6667
2 1 2 0 1	12	0.2927
2 1 2 0 1 1	7	0.5833
2 1 2 0 1 2	5	0.4167
2 1 2 0 2	17	0.4146
2 1 2 0 2 0	1	0.0588
2 1 2 0 2 1	4	0.2353
2 1 2 0 2 2	12	0.7059
2 1 2 1	38	0.2484
2 1 2 1 1	15	0.3947
2 1 2 1 1 1	5	0.3333
2 1 2 1 1 2	10	0.6667
2 1 2 1 2	23	0.6053
2 1 2 1 2 0	5	0.2174
2 1 2 1 2 1	4	0.1739
2 1 2 1 2 2	14	0.6087
2 1 2 2	74	0.4837
2 1 2 2 0	6	0.0811
2 1 2 2 0 0	1	0.1667
2 1 2 2 0 1	1	0.1667
2 1 2 2 0 2	4	0.6667
2 1 2 2 1	29	0.3919
2 1 2 2 1 1	14	0.4828
2 1 2 2 1 2	15	0.5172
2 1 2 2 2	39	0.5270
2 1 2 2 2 0	3	0.0769

2 1 2 2 2 1	10	0.2564
2 1 2 2 2 2	26	0.6667
2 2	769	0.5646
2 2 0	115	0.1495
2 2 0 0	20	0.1739
2 2 0 0 0	4	0.2000
2 2 0 0 0 1	1	0.2500
2 2 0 0 0 2	3	0.7500
2 2 0 0 1	5	0.2500
2 2 0 0 1 1	3	0.6000
2 2 0 0 1 2	2	0.4000
2 2 0 0 2	11	0.5500
2 2 0 0 2 0	4	0.3636
2 2 0 0 2 1	2	0.1818
2 2 0 0 2 2	5	0.4545
2 2 0 1	25	0.2174
2 2 0 1 1	9	0.3600
2 2 0 1 1 0	2	0.2222
2 2 0 1 1 1	4	0.4444
2 2 0 1 1 2	3	0.3333
2 2 0 1 2	16	0.6400
2 2 0 1 2 0	5	0.3125
2 2 0 1 2 1	1	0.0625
2 2 0 1 2 2	10	0.6250
2 2 0 2	70	0.6087
2 2 0 2 0	15	0.2143
2 2 0 2 0 0	5	0.3333
2 2 0 2 0 1	2	0.1333
2 2 0 2 0 2	8	0.5333
2 2 0 2 1	15	0.2143
2 2 0 2 1 1	4	0.2667
2 2 0 2 1 2	11	0.7333
2 2 0 2 2	40	0.5714
2 2 0 2 2 0	8	0.2000
2 2 0 2 2 1	5	0.1250
2 2 0 2 2 2	26	0.6500
2 2 1	188	0.2445
2 2 1 0	1	0.0053
2 2 1 0 2	1	1.0000
2 2 1 0 2 2	1	1.0000
2 2 1 1	95	0.5053
2 2 1 1 0	3	0.0316
2 2 1 1 0 1	1	0.3333
2 2 1 1 0 2	2	0.6667
2 2 1 1 1	29	0.3053
2 2 1 1 1 1	21	0.7241
2 2 1 1 1 2	8	0.2759
2 2 1 1 2	63	0.6632
2 2 1 1 2 0	29	0.4603
2 2 1 1 2 1	7	0.1111
2 2 1 1 2 2	27	0.4286
2 2 1 2	92	0.4894
2 2 1 2 0	14	0.1522
2 2 1 2 0 0	4	0.2857
2 2 1 2 0 1	3	0.2143
2 2 1 2 0 2	7	0.5000
2 2 1 2 1	29	0.3152
2 2 1 2 1 1	13	0.4483
2 2 1 2 1 2	16	0.5517
2 2 1 2 2	49	0.5326

2 2 1 2 2 0	5	0.1020
2 2 1 2 2 1	17	0.3469
2 2 1 2 2 2	27	0.5510
2 2 2	465	0.6047
2 2 2 0	63	0.1355
2 2 2 0 0	9	0.1429
2 2 2 0 0 0	1	0.1111
2 2 2 0 0 1	1	0.1111
2 2 2 0 0 2	7	0.7778
2 2 2 0 1	15	0.2381
2 2 2 0 1 1	4	0.2667
2 2 2 0 1 2	11	0.7333
2 2 2 0 2	39	0.6190
2 2 2 0 2 0	6	0.1538
2 2 2 0 2 1	6	0.1538
2 2 2 0 2 2	27	0.6923
2 2 2 1	116	0.2495
2 2 2 1 1	61	0.5259
2 2 2 1 1 0	2	0.0328
2 2 2 1 1 1	18	0.2951
2 2 2 1 1 2	41	0.6721
2 2 2 1 2	55	0.4741
2 2 2 1 2 0	10	0.1818
2 2 2 1 2 1	19	0.3455
2 2 2 1 2 2	26	0.4727
2 2 2 2	286	0.6151
2 2 2 2 0	39	0.1364
2 2 2 2 0 0	5	0.1282
2 2 2 2 0 1	5	0.1282
2 2 2 2 0 2	29	0.7436
2 2 2 2 1	73	0.2552
2 2 2 2 1 1	40	0.5479
2 2 2 2 1 2	33	0.4521
2 2 2 2 2	174	0.6084
2 2 2 2 2 0	19	0.1092
2 2 2 2 2 1	43	0.2471
2 2 2 2 2 2	112	0.6437

```
***A
JOB
MRC 001/00001011/  STATCAT.  R.J.BRADLEY
OUTPUT
0 LINE PRINTER 500 LINES
EXECUTION 3 MINUTES
COMPILER AA


begin
integer array x(-1:23), y(-1:23), z(-1:23)
integer set,f,i,j,n,e
real time,total
cycle i=0,1,23
x(i)=0
y(i)=0
z(i)=0
repeat
set= -1
total=0
time=0
1: read (e)
-> 2 if e=-3
total=total +1
time=time +e
->1 if e<50 or e>250
f=intpt(e*0.1)
y(set)=y(set) +e
x(set)=x(set) +1
z(set)=z(set) +e↑2
set=f
->1
2:caption total ś time ś is
print (time/36000,2,4)
caption hours
newline
caption total ś number ś of ś IRTs ś is
print (total,4,0)
newline
caption frequency, ś percentage, ś mean ś and ś SD ś after ś IRTs
newline
cycle i=5,1,23
newline
print (i,3,0)
spaces (4)
->3 if x(i)=0
print (x(i),6,0)
spaces (4)
```

```
print (x(i)/total,2,4)
spaces (4)
print (y(i)/x(i)*0.1,2,4)
spaces (4)
print (0.1/x(i)*sq rt (x(i)*z(i) - y(i)*2),2,4)
3: repeat
end of program
```

```
***A
JOB
MRC 001/00001002/ INFORMAT B15 8TH ORDER R.J.BRADLEY.
EXECUTION 3 MINUTES
COMPILER AA


begin
integer array x(-1:1,-1:1,-1:1,0:1), y(-1:1,-1:1,0:1), z(-1:1,0:1),
v(0:1)
integer array u(-1:1,-1:1,-1:1,-1:1,0:1), w(-1:1,-1:1,-1:1,-1:1,
-1:1,0:1)
integer array m(-1:1,-1:1,-1:1,-1:1,-1:1,-1:1,0:1), n(-1:1,-1:1,
-1:1,-1:1,-1:1,-1:1,-1:1,-1:1,0:1)
integer f,i,j,k,l,dog,hen,cat,total,pig,r,sow,t,p,q,not,bad
real a,b,c,d,e,g,h,s,man,wom
cycle i=0,1,1
v(i)=0
cycle j=0,1,1
z(i,j)=0
cycle k=0,1,1
y(i,j,k)= 0
cycle l=0,1,1
x(i,j,k,l)=0
cycle r=0,1,1
u(i,j,k,l,r) =0
cycle t=0,1,1
w(i,j,k,l,r,t) =0
cycle p=0,1,1
m(i,j,k,l,r,t,p)= 0
cycle q=0,1,1
n(i,j,k,l,r,t,p,q) =0
repeat
repeat
repeat
repeat
repeat
repeat
repeat
repeat
repeat
dog=-1
hen=-1
cat=-1
total=0
pig=-1
sow=-1
a=0
b=0
```

```
c=0
d=0
h=0
s=0
man=0
wom=0
not= -1
bad= -1
g=1/log(2)
1:read (e)
->2 if e=-3
f=0
total=total +1
if 150<e<200 then f=1
v(f)=v(f) +1
z(cat,f)=z(cat,f) +1
y(hen,cat,f) = y(hen,cat,f) +1
x(dog,hen,cat,f)=x(dog,hen,cat,f) +1
u(pig,dog,hen,cat,f)=u(pig,dog,hen,cat,f) +1
w(sow,pig,dog,hen,cat,f)=w(sow,pig,dog,hen,cat,f) +1
m(bad,sow,pig,dog,hen,cat,f)=m(bad,sow,pig,dog,hen,cat,f) +1
n(not,bad,sow,pig,dog,hen,cat,f)=n(not,bad,sow,pig,dog,hen,cat,f) +1
not=bad
bad=sow
sow=pig
pig=dog
dog=hen
hen=cat
cat=f
-> 1
2:  cycle i=0,1,1
-> 10 if v(i)=0
a=a - v(i)/total*log(v(i)/total)/g
cycle j=0,1,1
-> 9 if z(i,j)=0
b=b - z(i,j)/(total-1)*log(z(i,j)/(total-1))/g
cycle k=0,1,1
-> 8 if y(i,j,k)=0
c=c - y(i,j,k)/(total-2)*log(y(i,j,k)/(total-2))/g
cycle l=0,1,1
-> 7 if x(i,j,k,l)=0
d=d - x(i,j,k,l)/(total-3)*log(x(i,j,k,l)/(total-3))/g
cycle  r=0,1,1
-> 6 if u(i,j,k,l,r)=0
h=h - u(i,j,k,l,r)/(total-4)*log(u(i,j,k,l,r)/(total-4))/g
cycle t=0,1,1
-> 5 if w(i,j,k,l,r,t)=0
s=s - w(i,j,k,l,r,t)/(total-5)*log(w(i,j,k,l,r,t)/(total-5))/g
```

```
cycle p= 0,1,1
-> 4 if m(i,j,k,l,r,t,p)=0
man=man- m(i,j,k,l,r,t,p)/(total-6)*log(m(i,j,k,l,r,t,p)/
(total-6))/g
cycle q=0,1,1
-> 3 if n(i,j,k,l,r,t,p,q)=0
wom=wom - n(i,j,k,l,r,t,p,q)/(total-7)*log(n(i,j,k,l,r,t,p,q)/
(total-7))/g
3:repeat
4:repeat
5:repeat
6:repeat
7:repeat
8:repeat
9:repeat
10:repeat
wom=wom-man
man=man-s
s=s-h
h=h-d
d=d-c
c=c-b
b=b-a
newlines (5)
caption  averaged ś uncertainties
newline
caption  2 ś categories śśś reinforced ś and ś non-reinforced
newlines (2)
caption 8th ś order
spaces (5)
print (wom,1,8)
newlines (4)
caption 7 th ś order
spaces (5)
print (man,1,8)
newlines (4)
caption 6th ś order
spaces (5)
print (s,1,8)
newlines (4)
caption 5th ś order
spaces (5)
print (h,1,8)
newlines (4)
caption  4th ś order
spaces (5)
print (d,1,8)
newlines (4)
```

```
caption 3rd ś order
spaces (5)
print (c,1,8)
newlines (4)
caption 2nd ś order
spaces (5)
print (b,1,8)
newlines (4)
caption 1st ś order
spaces (5)
print (a,1,8)
end of program
```

```
***A
JOB
VU003/000, U EDIN, LP/9025   0000 BRADLEY PSYCHIATRY, TRIAD DIG
OUTPUT
0 LINE PRINTER 2000 LINES
COMPUTING 10000 INSTRUCTIONS
STORE 75/75 BLOCKS
COMPILER AA

begin
integer array x(-1:23,-1:23,0:23)
integer f,i,j,k,dog,hen
real e
cycle i=0,1,23
cycle j=0,1,23
cycle k=0,1,23
x(i,j,k)=0
repeat
repeat
repeat
dog=-1
hen=-1
1: read (e)
->2 if e=-3
f=intpt(e*0.1)
f= 23 if f> 23
x(dog,hen,f) = x(dog,hen,f) +1
dog=hen
hen=f
->1
2: newlines (4)
caption  Frequencies ≠ of ≠ overlapping ≠ triads
newlines (4)
cycle i=0,1,23
newlines (5)
print (i,8,0)
newlines (2)
cycle j=0,1,23
print (j,4,0)
repeat
newline
cycle j=0,1,23
newline
cycle k=0,1,23
print (x(i,j,k),4,0)
repeat
repeat
```

```
repeat
newlines (5)
caption  transition ś probabilities ś of ś triads
newlines (4)
cycle i=0,1,23
newlines (5)
print (i,8,0)
newlines (2)
cycle j=0,1,23
print (j,3,0)
space
repeat
newline
cycle j=0,1,23
newline
e=0
cycle k=0,1,23
e= e + x(i,j,k)
repeat
->3 if e<0
e = 1/e
3: cycle k=0,1,23
print (x(i,j,k)*e,1,2)
repeat
repeat
repeat
end of program
```

```
***A
JOB
MRC 001/00001012/  TRIAD RONALD J. BRADLEY
OUTPUT
0 SEVEN-HOLE PUNCH 80 BLOCKS
EXECUTION 9 MINUTES
COMPILER AA

begin
integer array x(-1:13,-1:13,0:13)
integer f,i,j,k,dog,hen
real e
cycle i=0,1,13
cycle j=0,1,13
cycle k=0,1,13
x(i,j,k)=0
repeat
repeat
repeat
dog=-1
hen=-1
1: read (e)
->2 if e=-3
f=intpt(e*0.1)
if 0<f<4 then f=0
if 5<f<10 then f=23
if f>10 then f=f-10
f= 13 if f> 13
x(dog,hen,f) = x(dog,hen,f) +1
dog=hen
hen=f
->1
2: newlines (4)
caption  FREQUENCIES ≠ OF ≠ OVERLAPPING ≠ TRIADS
newlines (2)
cycle i=0,1,13
newline
print (i,15,0)
space
caption IS ≠ THE ≠ FIRST ≠ MEMBER ≠ OF ≠ THE ≠ TRIAD
newline
spaces (4)
cycle j=0,1,13
print (j,3,0)
repeat
newline
cycle j=0,1,13
```

```
newline
print (j,2,0)
space
cycle k=0,1,13
print (x(i,j,k),3,0)
repeat
repeat
repeat
end of program
```

FREQUENCIES OF OVERLAPPING TRIADS

0 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	11	3	5	11	11	7	5	6	1	2	0	0	0	7
1	2	0	2	3	1	3	0	0	0	2	0	0	0	1
2	6	0	1	8	4	2	1	1	0	0	0	0	1	4
3	6	5	7	4	8	3	8	4	2	0	2	0	0	0
4	11	1	1	8	10	3	6	6	2	1	0	2	0	5
5	0	1	0	5	5	10	7	0	2	0	0	0	0	0
6	0	1	1	4	6	7	6	1	0	0	0	0	0	0
7	0	0	0	0	5	6	2	2	0	0	0	0	0	0
8	0	0	0	0	2	5	2	1	0	0	0	0	0	0
9	0	0	0	0	3	2	0	0	1	0	0	0	0	0
10	0	0	0	0	0	0	0	0	1	0	0	0	0	1
11	0	0	0	0	0	0	0	0	0	1	0	0	0	0
12	0	0	0	0	1	0	0	0	0	0	0	0	0	0
13	5	3	4	2	2	2	4	0	1	2	0	0	0	10

1 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	2	0	3	3	1	0	2	0	0	1	0	0	0	0
1	3	4	0	1	0	2	0	1	0	0	0	0	0	3
2	2	0	2	2	2	3	4	0	0	0	1	0	0	3
3	4	1	3	3	0	1	1	1	1	0	0	0	0	2
4	1	1	0	0	2	0	1	0	0	1	0	0	0	1
5	0	1	1	3	2	3	1	2	1	1	0	0	0	1
6	0	0	0	3	3	2	2	0	2	0	0	0	0	1
7	0	0	0	1	6	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	0	0	0	0	0	0	0	0
9	0	0	0	0	1	0	1	1	0	0	0	0	0	0
10	0	0	0	1	1	0	1	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12	0	0	0	0	0	0	0	0	1	0	0	0	0	0
13	1	4	0	1	1	1	1	0	1	0	0	0	0	7

2 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	4	2	5	3	4	1	4	0	0	0	2	0	0	8
1	2	2	3	2	2	0	3	0	1	0	0	0	0	0
2	6	1	3	6	1	5	1	1	0	0	0	1	0	3
3	6	2	3	7	5	5	4	2	1	0	1	0	0	3
4	4	1	1	3	8	3	0	0	1	0	1	0	0	4
5	0	1	1	6	7	6	3	0	1	0	0	0	0	2
6	0	0	0	4	5	6	0	0	0	0	0	0	0	0
7	0	0	1	1	3	1	1	0	0	0	0	0	0	1
8	0	0	0	0	1	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	1	0	0	0	0	0
11	1	0	1	1	0	0	1	0	0	0	0	1	0	1
12	1	1	0	0	0	0	0	0	0	0	0	0	0	1
13	3	3	2	1	4	4	0	1	1	2	0	0	0	6

3 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	14	2	2	14	8	7	5	5	1	0	0	1	0	5
1	1	3	5	2	2	3	2	0	0	1	3	0	0	6
2	6	6	7	5	5	6	4	3	1	0	0	2	0	6
3	10	4	5	8	9	8	6	5	0	0	0	1	0	1
4	16	5	4	5	12	3	2	5	2	1	3	0	1	3
5	1	0	2	6	14	6	3	1	0	0	0	0	0	3
6	0	1	2	10	9	8	7	0	0	0	0	0	0	1
7	0	0	0	5	6	7	2	0	0	1	0	0	0	0
8	0	0	0	1	1	3	0	0	0	0	0	0	0	1
9	0	0	1	0	1	1	0	0	0	0	0	0	0	0
10	1	0	1	0	1	2	0	0	0	0	0	0	0	1
11	0	0	0	0	0	0	0	0	0	0	0	1	0	1
12	0	0	0	0	1	0	0	0	0	0	0	0	0	0
13	2	3	3	4	0	3	3	1	3	0	1	1	2	6

4 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	31	6	10	13	29	13	7	4	6	3	0	0	0	7
1	1	2	2	4	1	2	2	5	0	0	0	1	0	1
2	4	3	7	4	6	4	4	2	0	0	0	0	1	2
3	6	7	7	8	10	6	8	7	0	1	0	0	0	8
4	12	5	11	9	14	7	9	5	3	2	1	0	0	10
5	0	0	1	4	15	11	2	0	1	0	0	0	0	3
6	0	1	3	6	12	8	9	2	2	0	0	0	0	1
7	0	0	1	3	13	5	4	4	0	0	0	0	0	0
8	0	1	0	1	6	4	1	0	0	0	0	0	0	1
9	0	0	1	0	2	7	4	1	0	0	0	0	0	0
10	1	0	2	1	1	1	2	1	0	1	2	0	0	0
11	1	0	0	0	0	0	1	0	0	0	0	1	0	0
12	0	0	1	1	0	0	0	0	0	0	1	0	0	0
13	6	4	3	5	5	2	4	2	1	0	1	0	1	9

5 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
2	2	1	3	3	2	3	1	0	0	0	0	0	0	2
3	11	4	18	12	13	6	4	1	1	2	1	0	1	3
4	50	1	11	24	18	9	9	5	3	4	1	1	1	7
5	0	1	4	23	42	40	10	5	1	1	0	2	0	2
6	0	1	4	5	10	18	4	2	1	1	0	0	0	0
7	0	0	0	0	3	5	1	0	0	0	0	0	0	0
8	0	0	1	0	1	1	2	3	1	0	0	0	0	0
9	0	0	0	1	0	0	0	0	1	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	2	0	1	0	0	0	0	0	0	0	0	0	0	1
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	1	0	1	1	2	0	4	2	1	0	1	0	5

6 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	3	2	0	0	0	0	0	0	0	0	0	0
2	1	1	1	4	1	0	0	0	0	0	0	1	1	0
3	12	2	5	4	11	2	4	0	1	0	1	1	0	4
4	17	1	1	8	15	5	9	3	0	2	3	0	1	1
5	0	0	4	12	30	28	9	0	0	0	0	0	0	4
6	0	1	0	8	8	16	10	0	0	0	0	0	0	1
7	0	0	0	0	1	3	1	0	0	0	0	0	0	0
8	0	0	0	0	1	2	1	1	1	0	0	0	0	0
9	0	0	0	0	0	0	0	0	1	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	1	0	1	0	0	0	0	0	1	0	1

7 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	1	1	1	0	0	0	0	0	0	0	0	0
3	3	2	2	4	0	1	1	0	0	0	0	0	0	1
4	10	5	3	4	4	2	4	3	2	1	1	0	0	4
5	0	1	1	6	13	15	3	0	3	0	0	0	0	0
6	0	0	0	2	4	7	2	0	0	0	0	0	0	0
7	0	0	1	0	0	6	0	4	0	0	0	0	0	1
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	1	0	0	0	0	1	0	0	0	0	0

8 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
2	0	1	0	1	0	1	0	0	0	0	0	0	0	2
3	0	0	0	2	1	1	0	0	0	0	0	0	0	0
4	4	0	2	2	2	0	1	2	0	1	1	0	0	1
5	0	0	1	4	8	4	2	1	0	0	0	0	0	1
6	0	0	0	0	2	3	3	0	0	0	0	0	0	0
7	0	0	0	1	0	0	3	1	0	0	0	0	0	0
8	0	0	1	0	0	0	0	0	0	0	0	0	1	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1	0	0	0	0	0	0	0	0	0	0	0	0	0
13	2	1	0	0	0	0	0	0	0	0	0	0	0	0

9 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	0	1	0	0	0	0	0	0	0	0	0	2
3	0	0	0	0	0	1	0	0	0	0	0	0	0	1
4	2	0	0	1	0	2	1	0	0	1	0	0	0	5
5	0	0	1	1	4	2	1	0	0	0	0	1	0	0
6	0	0	0	2	2	3	0	0	0	0	0	0	0	0
7	0	0	0	1	1	0	1	0	0	0	0	0	0	0
8	0	1	0	0	0	1	1	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	1
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	1	0	0	0	0	0	0	0

10 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	1	0	0	1	0	0	0	0	0	0	0	0
3	0	0	0	1	0	0	2	0	0	0	0	0	0	0
4	0	0	0	1	1	0	1	0	0	0	0	0	0	0
5	0	0	0	1	0	1	1	0	0	0	0	0	0	0
6	0	0	0	0	2	1	0	0	0	0	0	0	0	0
7	0	0	0	1	2	1	0	0	0	0	0	0	0	0
8	0	0	0	0	1	1	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	1	0	0	1
10	0	0	0	0	0	0	0	2	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	1	1	1	0	0	0	0	0	1	0	0

11 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	1	0	1	2	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	1	0	0	0	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	0	1
4	0	0	0	0	0	0	0	0	0	0	1	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6	0	0	0	1	0	1	0	0	1	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	2	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	1	0	0	1	0	0	1	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	1	0	1	0	0	0	1	0	0	0	1

12 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1	0	0	0	1	0	0	0	0	0	0	0	0	0	1
2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
3	1	0	0	0	1	0	0	0	0	0	0	0	0	0
4	0	0	0	0	1	1	0	0	0	0	0	0	0	1
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10	0	0	0	1	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	1	0	0	0	0	0	0	0	0	0	0	0	1

13 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	6	1	3	2	3	1	1	0	0	0	0	0	1	5
1	2	2	2	2	1	4	6	1	0	0	0	0	0	4
2	3	2	1	2	3	2	0	1	0	0	0	2	0	3
3	4	1	1	4	4	2	0	1	0	0	1	0	0	8
4	2	1	3	3	1	2	1	1	1	1	0	0	0	1
5	1	0	2	6	4	5	4	0	0	0	0	1	0	1
6	1	1	0	2	3	7	1	0	0	0	0	0	0	0
7	0	0	0	1	3	8	0	1	0	0	0	0	0	0
8	0	0	3	0	3	3	1	0	0	0	0	0	0	1
9	0	0	2	1	1	0	2	1	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	0	1	0	0	0	1
11	1	0	0	0	1	1	0	0	1	0	0	0	0	0
12	0	1	1	1	1	0	0	0	0	1	0	0	0	1
13	4	4	7	8	3	7	2	5	1	1	1	0	3	11

FREQUENCIES OF OVERLAPPING TRIADS

0 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	11	3	8	13	6	7	5	3	4	1	2	1	0	13
1	7	3	1	2	2	3	0	0	0	0	0	1	0	5
2	11	2	4	8	1	4	1	3	1	0	1	0	0	4
3	13	6	3	5	6	4	2	2	0	0	0	0	0	7
4	3	2	6	2	8	2	3	1	2	1	0	0	0	5
5	0	2	3	2	6	3	6	0	0	1	0	0	1	2
6	0	3	4	2	5	6	1	1	0	0	0	0	0	2
7	0	0	0	3	5	4	1	2	0	0	0	0	0	0
8	0	1	0	1	0	4	5	3	0	0	0	0	0	1
9	0	0	0	1	0	1	1	1	0	0	0	0	0	0
10	0	0	1	0	0	0	2	0	0	0	0	0	0	0
11	1	1	0	1	1	0	0	0	0	0	0	0	0	0
12	1	0	0	0	1	0	0	0	0	0	0	0	0	0
13	10	6	7	4	5	3	2	0	2	2	2	0	1	17

1 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	8	2	1	7	3	1	2	4	0	1	0	1	0	6
1	6	0	2	2	4	2	0	1	0	0	0	0	0	1
2	2	0	1	4	2	1	1	0	1	1	0	0	0	1
3	2	2	1	2	0	2	1	1	1	0	1	0	0	6
4	4	4	5	0	3	0	0	0	1	0	0	0	1	2
5	0	1	1	1	7	2	2	1	1	0	0	0	0	0
6	0	1	0	4	2	0	1	0	0	0	0	0	0	0
7	0	1	2	2	0	2	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1	0	0	0	0	0	0
9	0	0	0	1	0	0	1	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	1	0	0	0	0
11	0	0	0	0	0	1	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	4	0	4	3	5	3	3	1	1	0	0	0	0	5

2 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	11	2	6	8	3	2	3	0	0	1	0	0	0	7
1	4	0	3	2	1	1	0	1	0	0	0	0	0	5
2	4	1	6	3	4	4	1	0	1	0	0	0	0	1
3	7	3	5	3	2	4	4	1	0	0	1	1	0	3
4	3	2	4	6	1	2	2	0	0	1	0	0	0	5
5	0	0	0	2	3	3	7	1	0	0	0	0	0	1
6	0	0	1	1	0	1	1	3	0	0	0	0	0	0
7	0	0	0	1	5	0	1	0	0	0	0	0	0	0
8	0	0	1	3	0	3	0	0	1	0	0	0	0	0
9	0	2	0	1	0	2	1	0	0	0	0	0	0	0
10	1	0	0	0	0	1	3	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	4	4	3	1	2	0	0	2	0	1	0	1	2

3 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	13	5	8	11	10	7	6	0	2	0	0	1	0	12
1	2	3	1	4	2	2	4	0	0	0	0	0	0	3
2	2	6	3	6	2	1	0	1	1	2	2	0	0	2
3	4	2	8	4	6	1	4	3	0	1	0	0	0	5
4	4	3	3	5	3	2	4	0	4	1	0	0	0	5
5	0	2	1	5	2	6	4	0	2	0	0	0	0	2
6	0	2	2	5	6	2	1	0	1	0	0	0	0	1
7	0	1	3	1	1	4	1	0	0	0	0	0	0	1
8	0	0	0	0	2	2	3	0	0	0	0	0	0	0
9	0	0	1	0	0	1	0	0	0	0	0	0	0	0
10	0	0	0	1	1	2	0	0	0	0	0	0	0	0
11	0	0	0	0	0	1	0	0	1	0	0	0	0	0
12	0	0	0	0	0	1	0	0	0	0	0	0	0	0
13	4	4	2	2	6	4	3	1	1	1	0	0	0	4

4 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	23	8	13	3	8	8	7	7	7	1	1	1	2	13
1	4	4	4	1	4	3	2	2	0	1	0	0	0	5
2	4	5	3	0	8	2	0	1	3	0	1	0	0	6
3	12	2	3	2	4	3	4	0	3	0	0	0	0	1
4	5	6	3	4	5	5	2	2	1	1	0	2	0	3
5	0	3	1	4	8	8	5	3	0	0	0	0	0	1
6	0	1	0	1	4	12	0	1	1	0	0	0	0	2
7	0	1	1	0	1	4	1	1	1	0	0	0	0	0
8	0	0	1	2	2	4	1	2	2	0	0	0	0	0
9	0	0	0	2	0	1	0	1	1	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1	0	0	2	1	1	0	0	0	0	0	0	0	1
12	0	0	0	1	0	0	0	0	1	0	0	0	0	0
13	0	3	6	5	8	6	0	1	0	0	0	0	0	9

5 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	2	0	1	2	0	0	0	0	1	0	0	0	0	1
1	3	1	0	2	3	0	0	1	0	1	0	0	0	2
2	3	1	3	3	2	2	1	1	0	0	0	0	1	2
3	20	1	2	9	7	4	1	0	0	1	0	0	1	0
4	43	5	6	8	8	9	2	4	3	0	0	2	1	7
5	2	1	4	9	22	19	12	2	2	1	0	0	0	3
6	0	1	3	7	10	15	10	4	2	1	0	0	0	1
7	0	0	0	1	2	7	4	1	0	1	0	0	0	1
8	0	0	1	1	0	0	2	1	0	0	0	0	0	0
9	0	0	0	0	1	0	1	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	1	0	0	0	0	0	0	0	0	0
13	4	0	1	1	3	1	0	1	0	0	0	0	0	1

6 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2	1	0	1	3	0	1	1	0	0	0	0	0	1
2	4	2	3	2	2	0	0	0	0	0	0	0	0	0
3	5	1	0	4	4	2	2	0	0	0	2	0	0	2
4	21	2	1	4	2	5	3	3	2	0	0	0	0	3
5	2	1	3	10	16	22	4	5	0	0	0	0	0	2
6	0	1	0	1	11	18	12	4	1	1	0	1	0	0
7	0	0	1	1	1	8	9	1	2	0	0	0	0	1
8	0	0	0	1	1	1	2	0	0	0	0	0	0	0
9	0	0	0	0	0	1	1	1	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	1	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	3	1	0	0	0	1	0	0	0	0	0	0	0	1

7 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	1	0	0	0	0	0	0	0	0	0	1
2	4	0	0	1	1	1	0	0	0	1	0	0	0	0
3	3	0	0	2	0	1	0	0	2	0	0	1	0	1
4	7	2	1	2	2	2	1	0	0	0	0	0	0	0
5	1	0	3	4	14	6	6	3	0	0	0	0	0	1
6	0	0	0	1	3	6	9	5	0	0	0	0	0	0
7	0	0	0	0	1	2	3	2	1	1	0	0	0	0
8	0	0	0	0	1	1	2	1	1	0	0	0	0	0
9	0	0	0	0	0	1	0	0	0	0	1	0	0	1
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	1	0	0	2	0	0	0	0	1	0	0	0	0

8 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	1	0	0	0	0	0	1
3	3	2	0	1	2	2	1	1	0	0	0	0	0	2
4	4	0	0	0	2	0	1	0	0	1	0	1	0	2
5	0	0	0	5	8	3	1	0	0	0	0	0	0	0
6	0	1	2	0	0	2	6	4	0	1	0	0	0	0
7	0	0	0	0	1	3	1	2	2	1	0	0	0	0
8	0	0	0	2	1	0	1	1	1	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	1	0	0	0	0	0	0	0	0

9 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	1	0	0	0
2	0	0	0	0	0	1	0	0	0	0	0	0	0	0
3	1	1	1	2	2	0	0	0	0	0	0	0	0	1
4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
5	1	0	0	3	2	0	0	2	0	0	0	0	0	0
6	0	0	0	0	2	1	1	1	0	0	0	0	0	0
7	0	0	1	0	0	1	2	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	1	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	1	0	0	0	0	0	0	0	0	0	0	0	0	1

10 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	1	0	0	0	0	0	0	0	0
3	0	0	1	0	0	0	0	0	0	0	0	0	0	0
4	1	0	0	0	0	0	0	0	0	0	0	1	0	0
5	0	0	0	0	1	1	1	0	0	0	0	0	0	0
6	0	0	1	0	0	2	2	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	1	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	1	0	0	0	0	0	0

11 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	1	1	0	0	0	0	0
4	0	1	0	0	0	1	0	0	0	0	0	0	0	0
5	0	0	0	0	1	0	2	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	1	0	0	0	0	0	0	0

12 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	1	0	1	0	0	0	0	0	0	0
5	0	0	0	0	0	1	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	1	0	0	0	0	0	0	0	0
8	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0

13 IS THE FIRST MEMBER OF THE TRIAD

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	9	3	3	4	3	1	0	1	1	0	0	0	0	7
1	6	5	2	1	1	5	1	1	1	0	0	0	0	5
2	8	0	2	6	4	0	3	0	1	2	1	0	0	3
3	4	1	3	4	1	1	1	3	0	0	0	0	0	5
4	7	2	4	3	3	5	3	0	1	0	0	0	0	6
5	1	3	3	1	8	3	4	0	0	0	0	0	0	0
6	0	0	0	0	3	0	6	1	0	0	0	0	0	0
7	0	0	0	1	0	2	1	1	0	0	0	0	0	1
8	0	0	0	2	4	2	0	0	1	0	0	0	0	0
9	0	1	0	2	0	1	0	1	0	0	0	0	0	1
10	1	1	0	0	1	0	0	0	0	0	0	0	0	1
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	1	0	0	0	0	0	1	0	0	0	0	0	0
13	6	9	6	5	4	2	1	1	3	2	1	0	0	16

```
***A
JOB
MRC 001/00001004/ DISTANCE NAP R.J.BRADLEY.
EXECUTION 2 MINUTES
COMPILER AA


begin
integer array  m(0:30), n(0:30)
integer i,j,f,set
real e,x,total
cycle i=1,1,30
m(i)=0
n(i)=0
repeat
1: set=0
-> 2
4: n(set)=n(set) +1
6: read (x)
-> 3 if x=-3
-> 1 if 150<x<200
-> 6 if x<50
-> 7
2: read (e)
->3 if e=-3
->1 if 150  <e<200
->4 ife< 50
7:set=set +1
->1 if set> 30
m(set)=m(set) +1
->2
3:   cycle i=1,1,30
print (i,3,0)
spaces (3)
print(m(i),5,0)
spaces(5)
print(n(i),5,0)
newline
repeat
end of program
```

DISTANCE	FREQUENCY	NO OF Bs
1	516	119
2	357	58
3	243	25
4	171	17
5	112	14
6	68	7
7	47	8
8	32	3
9	24	5
10	15	2
11	12	3
12	8	3
13	8	1
14	5	1
15	3	1
16	2	0
17	2	1
18	2	1
19	1	1
20	1	0
21	1	0
22	1	0
23	0	0

DISTANCE	FREQUENCY	NO OF Bs
1	380	134
2	268	42
3	189	26
4	127	19
5	95	15
6	74	11
7	61	9
8	44	7
9	34	8
10	23	4
11	18	8
12	12	2
13	9	2
14	9	2
15	6	1
16	4	2
17	1	1
18	1	0
19	1	0
20	1	0
21	1	1
22	1	0
23	1	0
24	1	0
25	1	0
26	0	0

```
***A
JOB
MRC 001/00001005/  REINFORCEMENT NAP R.J.BRADLEY
EXECUTION 2 MINUTES
COMPILER AA


begin
integer array m(0:30), n(0:30)
integer i,j,f,x,set
real e,total,y
cycle i=0,1,30
m(i)=0
n(i)=0
repeat
->2
5: set=0
1: set=set +1
->4
2:set=0
4: read (e)
->3 if e=-3
->1 if 150<e<200
-> 4 if e<50
m(set) =m(set) +1
read (x)
-> 3 if x=-3
-> 5 if 150<x<200
if x<50 then n(set) =n(set) +1
-> 2
3:  cycle i=1,1,30
print (i,3,0)
spaces (3)
print (m(i),5,0)
spaces (5)
print (n(i),5,0)
newline
repeat
end of program
```

NO OF SRs	FREQUENCY	NO OF Bs
1	282	47
2	134	37
3	43	15
4	22	8
5	10	4
6	11	3
7	6	2
8	5	2
9	1	0
10	1	1
11	0	0

NO OF SRs	FREQUENCY	NO OF Bs
1	197	57
2	106	48
3	20	8
4	10	1
5	17	7
6	8	5
7	7	2
8	5	2
9	3	2
10	1	1
11	1	1
12	1	0
13	1	0
14	2	0
15	0	0

```
***A
JOB
MRC 001/00001019/    FRACTIONS RONALD J. BRADLEY
OUTPUT
0 SEVEN-HOLE PUNCH 90 BLOCKS
EXECUTION 8 MINUTES
COMPILER AA

begin
integer array x(1:3,-1:23,0:23)
real array y(1:3,0:23),t(1:3)
integer f,i,j,n,dog,set,k,r,m
real e,total
cycle i=1,1,3
t(i)=0
cycle j=0,1,23
y(i,j)=0
cycle k=0,1,23
x(i,j,k)=0
repeat
repeat
repeat
set=-1
total=0
dog=1
1: read (e)
dog=1ife=-1
dog=2ife=-4
dog=3ife=-5
->2 ife=-3
f=intpt(e*0.1)
f=23iff>23
y(dog,f)=y(dog,f) +1
x(dog,set,f)=x(dog,set,f) +1
set=f
t(dog)=t(dog) +1
->1
2: cycle i=1,1,3
newlines(4)
caption FRACTION
print (i,2,0)
newlines (6)
spaces (10)
caption conditional ś probabilities
newlines (2)
cycle j=0,1,23
newlines (6)
```

```
spaces (10)
caption the ≠ first ≠ number ≠ of ≠ the ≠ binary ≠ combination ≠ is ≠
print (j,2,0)
newline
e=0
cycle k=0,1,23
e=e+x(i,j,k)
repeat
spaces (10)
if (y(i,j)*100/t(i))<4 then caption  this ≠ combination ≠ occupies
≠ less ≠ than ≠ 4 ≠ percent
if (y(i,j)*100/t(i))<4 then -> 6
e=1/e
newlines (3)
spaces (4)
caption 0
spaces (8)
caption .1
spaces (8)
caption .2
spaces (8)
caption .3
spaces (8)
caption .4
spaces (8)
caption .5
newline
spaces (4)
cycle r=0,1,50
caption -
repeat
cycle k=0,1,23
m=0
newline
m= intpt(x(i,j,k)*e*100)-1
print (k,2,0)
space
caption |
-> 4 if m=-1
-> 3 if m=0
cycle n=0,1,m
caption X
repeat
3: caption |
4: repeat
6: repeat
repeat
newlines (6)
end of program
```

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